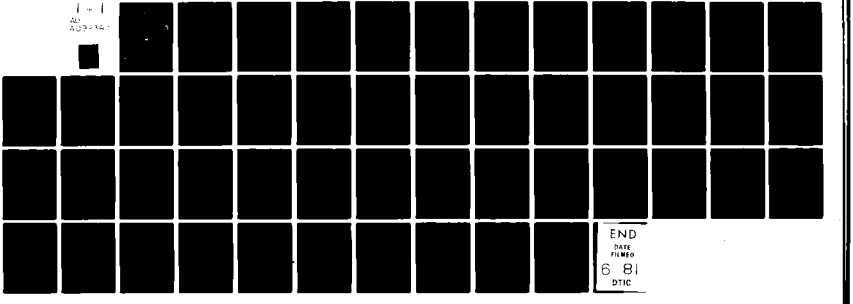
AD-A099 387 OFFICE OF NAVAL RESEARCH LONDON (ENGLAND) F/G 5/2
EUROPEAN SCIENTIFIC NOTES, VOLUME 35, NUMBER 3,(U)
MAR 81 T C CHESTON, D J PETERS
UNCLASSIFIED ESN-35-3 NL



OFFICE OF NAVAL RESEARCH
LONDON

LEVEL II

12

EUROPEAN SCIENTIFIC NOTES

ESN 35-3

31 MARCH 1981

Distributed by the
Office of Naval Research Branch Office,
London

This document is issued primarily for the information of U.S. Government scientific personnel and contractors. It is not considered part of the scientific literature and should not be cited as such.

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: 35-3 / 2. GOVT ACCESSION NO.: AD-A099 387	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): EUROPEAN SCIENTIFIC NOTES	5. TYPE OF REPORT & PERIOD COVERED: Monthly Publication-March 1981
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): T.C. Cheston and Don J. Peters, editors	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: U.S. Office of Naval Research Branch Office London Box 39, FPO NY 09510	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE: 31 March 1981
	13. NUMBER OF PAGES: 44
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Chemistry
Communications
Computer Sciences
Education
Engineering
Materials Science
Ocean Sciences
Operations Research
Physics

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the Scientific Literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with, members of the

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

scientific staffs of the United States Air Force's European Office of Aerospace Research and Development and the United States Army Research and Standardization Group. Articles are also contributed by visiting Stateside scientists.

EUROPEAN SCIENTIFIC NOTES
OFFICE OF NAVAL RESEARCH
LONDON

Edited by T.C. Cheston and Don J. Peters

31 March 1981 Volume 35, No. 3

ESN 35-3 (1981)

European Scientific Notes is a Class I Periodical prepared and distributed by the Office of Naval Research London in accordance with NAVEXOS-P-35. Prepared and submitted by the scientific and technical staff.

W.J. CONDELL
Chief Scientist

P.F. GIBBER
Captain, USN
Commanding Officer

CHEMISTRY

CHEMICAL RESEARCH AT THE INSTITUT FUR STRAHLENCHEMIE, MULHEIM

The Institut für Strahlenchemie (Radiation Chemistry) is located in Mülheim in northern Germany. Mülheim, with a population of over 190,000, is a modern city on the southwestern fringe of the industrial Ruhr area. The beautiful Ruhr river, which flows through the city, and the many parks combine to create a very pleasant environment. The city traces its origins back 1100 years to the Broich castle, the oldest remaining walls of which date to 883 AD. This castle has been impressively restored by the town.

The Institut für Strahlenchemie was founded in 1958 as a unit attached to the Max-Planck-Institut für Kohlenforschung (Coal Research). This former institute is financed by the Max Planck Gesellschaft (MPG), a research organization whose institutes are established to carry out scientific work for the benefit of the public. The activities of the Max Planck Institutes are principally in the fields of natural science and the humanities. The institutes in particular devote their attention to new problems which are not sufficiently developed for university research or problems that are less suited for the university because of the scope and structure of the research. The MPG operates 50 institutes, research units, and project groups distributed throughout the Federal Republic of Germany and West Berlin. Approximately 80% of the funds used by the MPG comes from the federal government and the state governments.

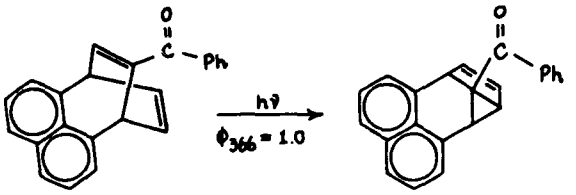
The Max-Planck-Institut für Kohlenforschung in Mülheim was founded in 1912. The first director of the institute was Prof. Franz Fischer and it was during the period of 1920 to 1940 that the Fischer-Tropsch synthesis was developed. This process, which converts carbon monoxide and hydrogen derived from coal into hydrocarbons, has been important in the past, but with the energy crisis it will receive increasingly more attention in the future. A change in research emphasis came with the appointment of Prof. Karl Ziegler in 1943 as director. A study of organometallic chemistry was initiated which eventually led to the development of the Ziegler catalysts. These catalysts, for which Ziegler was awarded the Nobel Prize for chemistry in 1963, are used for the conversion of olefins into plastics. In 1974 products valued at DM4,000,000 ($2M) were manufactured by processes developed at this institute. It is, therefore, not surprising that the Institute for Coal Research is unique among Max Planck institutes in that it is an autonomous foundation which is financed almost entirely from the income of its research activities. The present director of this institute is Prof. Günther Wilke.

The Institute for Radiation Chemistry is involved in a wide variety of research areas including: (1) chemical effects of ultraviolet radiation, γ-rays, and high-energy electrons on organic and biological systems; (2) new methods of synthesis; (3) organic and organometallic photochemistry; and (4) theoretical chemistry. A specific major research effort of the institute involves the radiation chemistry of deoxyribonucleic acid (DNA) and model compounds. The institute has a staff of approximately 170 persons of whom more than 30 are senior scientists with an additional 50 guest scientists. The 3 directors of the institute are Prof. Oskar Polansky, Prof. Dietrich Schulte-Frohlinde, and Prof. Kurt Schaffner. The institute is extremely well equipped with modern instruments for chemical research. Two 3 MeV van de Graaff electron accelerators are available for pulse radiolysis investigations. A cobalt-60 source is also used for radiation chemistry experiments. Described below are but a few examples of the elegant research being conducted at this institute.

The mechanism of the photosensitized rearrangement of β,γ-unsaturated ketones has been a continuing area of study for Schaffner and his collaborators. They have recently studied the reactivity of the excited triplet of 3-acetyl-3-methylcyclopentene generated by the thermal decomposition of high-energy peroxides, 1,2-dioxetanes. The product distribution obtained from the reaction was compared with that from direct and triplet-sensitized photolysis. At 25°C, direct irradiation gave principally the 1,3-acetyl shift product, whereas triplet sensitization by acetone favored the oxadi-π-methane rearrangement. Schaffner has indicated that the results of this study point to the existence of two triplet states of 3-acetyl-3-methylcyclopentene with differing reactivities. The novel observation is that these triplet states are apparently not populated equally by the thermal chemiexcitation from the peroxide and the photosensitized mode. Molecular orbital calculations by Polansky and Dr. G. Olbrich are in agreement with the above results and indicate that there are two triplet states with predominantly

$^3n,\pi^*$ and $^3\pi,\pi^*$ character with an energy separation of no more than 12 kJ/mol.

An interesting study of the photoisomerization of the bicyclo[3.2.2]nonanapthalene 1 to give the tricyclic semibullvalene-type product 2 has been carried out by Schaffner's group. This photoreaction can be effected by either direct irradiation with 316 or 366 nm light or with triplet sensitizers of greater than 60 kcal. Deuterium labeling experiments have been carried out to elucidate the mechanism. Irradiations were conducted in 2-methyltetrahydrofuran matrices, and electron spin resonance and infrared spectra were recorded at 77 K.



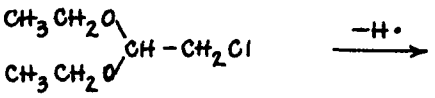
1 2

This work has provided the first direct evidence of the intermediacy of a biradical intermediate (or a category of biradical intermediates) in di-π-methane photochemistry and confirms the stepwise mechanism for the photorearrangement of barrelenes that was originally postulated by Prof. H.E. Zimmerman (Univ. of Wisconsin). It has also been observed that the inter conversion of 1 ⇌ 2 can be effected thermally without the intervention of light. The thermal transformation of 1 → 2 represents the first example of a ground-state counterpart of a di-π-methane photorearrangement. A thermally equilibrated mixture of 98.8% 1 and 1.2% 2 was obtained when either of the two components was heated in benzene at 220°C. The rearrangement of 2 → 1 can also be carried out at room temperature in the presence of strong electrophiles; e.g., treatment of 2 in chloroform with trimethylsilyl trifluoroacetate resulted in clean conversion to 1. Schaffner has pointed out that the sequence of the photochemical rearrangement of 1 → 2 which occurs with 100% efficiency and the catalytic reversal of 2 → 1 in the dark represents a model of a cycle for chemical light energy storage which can be conducted without detectable destruction of the reactants.

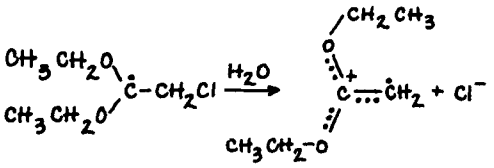
Dr. Sylvia Braslavsky, Schaffner, and co-workers have recently been involved in a thorough study of the photophysical properties of biliverdin and its dimethyl ester. Biliverdin is a precursor of the yellow bile pigment bilirubin in heme catabolism and has received the increasing attention of several research groups in the last few years because of its close structural relationship to the chromophoric group of phytochrome. Phytochrome is the plant photoreceptor which triggers the photomorphogenic processes in plants. This group has been particularly careful in the preparation and purification of the biliverdin by high pressure liquid chromatography and has carried out its studies on a sample of unequivocally established homogeneity. There apparently has been considerable difficulty in the purification of this compound by other groups, the result of which has been some erroneous data in the literature. The fluorescence of the biliverdin dimethyl ester has been studied under a variety of conditions. During the course of this work, it was observed that when a neutral solution was kept standing in the dark at ambient temperature, or when an acidic solution was neutralized by base, an additional fluorescence was produced. This appearance of a new fluorescence upon "aging" of the solution may well be the source of some of the confusion in the literature. The structure of the species that results in this new fluorescence is not known, but the nucleophilic addition of solvent to the biliverdin appears a likely cause. Additional studies by this group have employed high field magnetic resonance spectroscopy (300 MHz) with double resonance decoupling and nuclear Overhauser effect (NOE) experiments. Another technique used by this group to investigate the conformation of isomeric biliverdins in solution was ethyl (S)-(-)-lactate-induced circular dichroism at ambient temperature. These results all provide evidence for a helical conformation for biliverdin in solution. A ^{1}H-NMR kinetic study of a derivative of biliverdin has shown that the barrier to interconversion of the helical conformations is 42 kJ/mol in the range of 205 to 195 K.

Schulte-Frohlinde and his collaborators are concerned primarily with the reactions of substrates under ^{60}Co γ-radiolysis and pulsed electron radiolysis. Model compounds selected for study are designed to provide further information about the mechanism of radiation-mediated DNA damage. The formation and structure of 1,1-dialkoxyalkene radical cations in aqueous solution have recently been studied by Schulte-Frohlinde. The structures of the radical cations have been elucidated by *in situ* electron spin resonance (ESR) experiments. The reactions are initiated by hydrogen atom abstraction from substrates such as 3 by triplet excited acetone, HO· radicals, or $SO_4^{\cdot-}$ radicals upon UV irradiation

of acetone, H_2O_2 or $S_2O_8^{2-}$, respectively. Subsequent heterolytic dissociation yields the radical cation 4 and the leaving group.



3



4

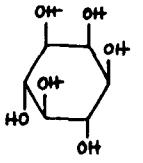
Schulte-Frohlinde has found that the radical cations are best observed at pH <5. Radical cations have been generated from both open-chain and cyclic acetals with various leaving groups such as Cl, Br, or CH_3CO_2 groups β to the acetal CH moiety. Open-chain radical cations such as 4 were found by ESR to exist in Z,E-conformations as evidenced by two sets of a_δ^H couplings. The kinetics of the reactions have been studied by pulse conductivity methods using 2.8 MeV electron pulses of 1 ms duration from the van de Graaff generator.

In studies directed toward providing additional insight into the mechanism of radiation-induced DNA chain breaks, Dr. Clemens von Sonntag and co-workers have been involved in research on the reactions of hydroxyl radicals with various substrates. Recently they have investigated the hydroxyl radical-induced oxidation of 2-methyl-2-propanol in oxygenated aqueous solution. The various products from the reaction were characterized, and pulse radiolysis techniques were employed to study the kinetics of the reaction. ^{60}Co γ-radiolysis of aqueous solutions generates as the primary reactive species hydroxyl radicals, solvated electrons, and hydrogen atoms. Hydroxyl radicals attack the alcohol preferentially abstracting carbon-bound hydrogen atoms, generating the 2-hydroxyl-2-methylpropyl radical. Subsequent addition of oxygen to this radical at a diffusion controlled rate forms the corresponding peroxyl radical. Von Sonntag has isolated several products from this reaction, one of which is a peroxide. A mechanism for the formation of the peroxide has been proposed and involves the intermediacy of tetroxide. A pulse radiolytic investigation of this reaction has been carried out using the 2.8 MeV van de Graaff generator with electron pulses of 1 μsec duration and doses of 2.5 to 20 J/kg. The kinetics of the reaction were followed by monitoring transient conductivity changes produced immediately after the pulse.

Dr. Claude Nicolau and Prof. Klaus Gersonde (Rheinisch-Westfalische Technische Hochschule, Aachen, FRG) have collaborated to develop a procedure for dramatically increasing the O_2 release capacity of red blood cells (RBC) in circulating blood by up to 280% with the possibility of greatly improved O_2 supply to tissues. Experiments have also shown that these modifications of RBC can last over a significant period of time and suggest improved procedures for the storage of blood.

At a normal O_2 partial pressure of 100 mm Hg in the lungs, approximately 95% of the hemoglobin (Hb) is saturated with O_2. Therefore, under physiological conditions the O_2 loading of RBC proceeds efficiently. Less efficient, however, is the O_2 release in the peripheral bloodstream where O_2 has to be dissociated from the oxygenated Hb against a relatively high O_2 partial pressure. Consequently, only about 25% of the oxygenated Hb may be deoxygenated with about 75% being returned to the lungs with the veinous blood. Therefore, as Nicolau and Gersonde point out, a major fraction of the O_2 which is bound to Hb is not released and could be available as a source of O_2.

Other workers had shown in the early 1970s that polyphosphates such as *myo*-inositol hexaphosphate (IHP) decrease the O_2 affinity of Hb (or increase the O_2 release capacity). *myo*-Inositol (5) is a hexahydroxycyclohexane which occurs naturally and is widely distributed in microorganisms, higher plants and animals. In plants it is found as the fully phosphorylated derivative, phytic acid. IHP is the strongest known allosteric effector of hemoglobin decreasing dramatically the O_2 affinity. The interaction of IHP and isolated Hb has been studied extensively, but because water-soluble polyphosphates such as IHP cannot permeate the erythrocyte membrane in order to bind the Hb, there had been no studies of IHP with intact red blood cells.



5

Nicolau and Gersonde have found that the interaction of RBC with lipid vesicles with encapsulated IHP leads to an irreversible incorporation of IHP in RBC. Lipid vesicles consisting of one or more concentric lipid bilayers enclosing an aqueous compartment can transfer the water-soluble and membrane-impermeant IHP by a process of fusion of the outer lipid layer of the vesicle with that of the RBC membrane with concomitant delivery of the encapsulated IHP into the RBC. These workers have employed in their studies unilamellar vesicles with a diameter of less than 500 Å which have entrapped 0.19 M IHP solution in isotonic saline buffer. The bilayer structure consists of a lipid mixture of phosphatidylcholine, phosphatidylserine and cholesterol in an 8:2:7 molar ratio, respectively. The vesicles are formed by ultrasonic dispersion with separation of the unilamellar vesicles from the larger multilamellar vesicles by ultracentrifugation.

To take advantage of the IHP benefits for the treatment of blood, Nicolau and Gersonde indicate that it would be necessary to separate the RBC from other blood constituents, since the vesicles will also be incorporated by the lymphocytes or will interact with serum lipoproteins resulting in loss of the entrapped IHP. Thus, the incorporation of IHP into RBC is only possible *in vitro*; i.e., extracorporal. After washing, the IHP-loaded RBC can be resuspended in the blood plasma and the treated blood can be retransfused to the animal.

No back transport of IHP across the erythrocyte membrane has been detected. Experiments over a 40-day period show no significant decrease in the concentration of the IHP bound to Hb, a result of the fact that RBC have no hydrolytic enzymes with IHP specificity. It has also been discovered that CO_2 transport by RBC is enhanced by bound IHP. Unlike RBC, which when stored at 4°C in stabilizer solutions undergo a progressive increase in O_2 affinity and depletion of ATP, the IHP-treated RBC exhibit an enhanced O_2 release capacity which remains unchanged over an extended period.

Nicolau and Gersonde point to several potential applications of erythrocytes with incorporated IHP, one of which involves improved O_2 supply to the tissues under low O_2-partial pressure in air such as at high altitude. Preliminary experiments with rats have shown that incorporation of IHP into the RBC enables the rats to adapt to reduced O_2 partial pressures.

Polansky, H. Karpf, and M. Zander have observed the first example of a photochemically induced addition of maleic anhydride to a polycyclic aromatic hydrocarbon of the type that contains a peripheral cisoid C^4-unit. Because molecular orbital calculations by Polansky had shown that chrysene was not expected to undergo a Diels-Alder reaction in the ground state, but should react photochemically in the S_1 state, Polansky and co-workers have recently been investigating the photochemical addition of maleic anhydride to chrysene.

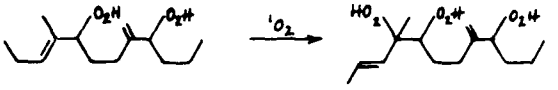
Finally, it is a personal pleasure to report that Prof. Günther O. Schenck, who was instrumental in the establishment of the Institute for Radiation Chemistry and who with his collaborators developed the field of photosensitized oxidation, is actively involved in a new photochemical project. Schenck is involved in the design of photochemical reactors for use in disinfecting water. Various geometries of the photoreactors and a variety of ultraviolet light sources are being considered. Calculations of doses, degermination capacities, and costs for the degermination are being carried out. (A. Paul Schaap)

PHOTOOXYGENATION RESEARCH IN STRASBOURG

Strasbourg, the capital of Alsace, is one of the largest cities in France. Only the Rhine separates Germany from the Alsace and Lorraine Provinces; and this region, while passionately French, also often looks and sounds German. This picturesque city with its many canals and carved, timbered houses is dominated by its stunning cathedral, which was constructed of rose-colored stone and completed in Gothic style in the 13th century. The 470-foot spire is visible from anywhere in the city. Because of its location on the Rhine, Strasbourg is one of the most important ports in France. The city is the seat of the Council of Europe and the meeting place of the European Parliament.

I visited Prof. Charles Tanielian, who is a member of the faculty of the Institute of Chemistry at the University of Louis Pasteur in Strasbourg. His Laboratory of Applied Organic Chemistry is located in the approximately 14-story research tower of the institute. Tanielian's group has recently been involved in an investigation of the use of chlorophyll as an efficient sensitizer for the photooxygenation of organic substrates. They have found that a commercially available "oil-soluble" chlorophyll is an inexpensive and useful alternative to chlorophyll a. This material appears to be significantly more stable under photooxygenation conditions than the purified chlorophyll a. The kinetics of the oxidation of tetramethylethylene and 2-methyl-2-pentene have been studied at ambient temperature in benzene solution.

Tanielian's principal research efforts are directed towards gaining an understanding of processes involved in the photooxidative degradation of polymers. It is known that hydroperoxides are key initiators in the degradation of polymers. These peroxides decompose under the effects of heat or light to yield radicals which subsequently initiate the autoxidative reduction of polymer chains. Therefore, Tanielian has been investigating the photooxygenation of polyisoprene model compounds. Reactions of singlet oxygen with diene substrates such as *trans,trans*- and *cis,cis*-4,8-dimethyl-4,8-dodecadiene have been studied. The hydroperoxidic products of the reaction were analyzed by conversion to the corresponding trimethylsilyl ethers and subsequently characterized by vapor phase chromatography-mass spectrometry techniques. Mono- and dihydroperoxides of various structures were obtained. Analysis of the kinetics of the reactions indicated that the *trans*-isomers were in general more reactive than the *cis*-isomers. Tanielian observed a deactivating effect of approximately a factor of two by the first hydroperoxide group upon the rate of addition of singlet oxygen to give the dihydroperoxide. He has noted that extended photooxygenation of these substrates can result in the formation of trihydroxides as shown below. Tetraadducts were not seen. He has also studied the reactions of dihydromyrcene and the allylic alcohols, geraniol and linalol.



Tanielian has a laboratory which is well-equipped for these investigations; and although he presently has a relatively small number of collaborators with him, he is making some very significant contributions in the area of photooxygenation and the photodegradation of polymers. (A. Paul Schaap)

COMMUNICATIONS

THE UK NATIONAL PHYSICAL LABORATORY: IT PAYS TO ADVERTISE

The National Physical Laboratory (NPL) Britain's counterpart to the National Bureau of Standards in the US, is well known for its activities in metrology and numerical analysis. (See *ESN* 34-1:35 [1980] and *ESN* 32-4:137 [1978], respectively.) The powers that be at NPL must have felt that publicity for some of its other activities were in order, so they arranged to have a prime-time television news program broadcast a demonstration of their speech recognition system. It was through that broadcast that I became aware of their work in speech processing.

Brian E. Pay, the leader of the NPL group working in that field, was my host for the visit. He admitted freely that they generally have not published their results in outside journals nor have they presented any papers at any recent conferences. So he wasn't at all surprised that I hadn't been aware of their existence. (The TV broadcast and a subsequent discussion in the local technical press may indicate a change of attitude in their publicity policy.) He and three other engineers make up the Speech Recognition Group, a part of NPL's Division of Numerical Analysis and Computer Science. As their group's name suggests, their speech-related studies are limited: they do *not* consider speaker recognition, speech synthesis, bandwidth compression, etc.; but they have been working in their chosen specialty for 12 years and their current development is one which provides some interesting capabilities for a particular type of environment.

Pay described that environment in these terms: consider the cockpit of a commercial airliner of the future where many of the controls, including knobs, switches, joy-sticks, gauges and indicator lamps are replaced by an alpha-numeric display together with a speech recognition system through which the pilot controls many of the aircraft's systems. In the course of carrying out the flying duties on a long trip, not much of the pilot's time is spent making operational adjustments through the control systems. There is a social rather than an operational flavor in the conversations held with the co-pilot and the rest of the crew, and in the announcements to the passengers. When the situation demands that aircraft systems' control options be exercised, those duties may still demand only intermittent concentration, but in any case, they will generally be carried out through a well defined series of context-related choices and actions. For the speech recognition system on board, the implications are these: control-related commands must be recognized reliably, in real time, in the midst of a (possibly varying) noisy background, and in the midst of continuous conversational speech. For operational reasons, the system should operate in such an environment without imposing too tight a discipline

on the user's speech patterns and without requiring the user to have to turn the system on and off while it is being used. Furthermore, the system must be practical with respect to the volume of hardware involved. In effect, the capability required and the practical limitations imply that the system must operate by taking advantage of context-related syntax. The same set of system characteristics are suitable in other applications such as general office automation, computer-assisted manufacturing processes, interactive computer-aided design, banking, and military systems.

There are developmental and even some commercially-available devices which can recognize a prescribed set of words spoken by either one or a few speakers, either as isolated words or as connected sets. The NPL system differs in that genuine continuous speech is treated in real time by a simple hardware configuration. Pay indicated that under suitable restrictions to the size of the key-word vocabulary, the number of English speakers that can be accommodated is quite large, including those using most of the regional dialects in England. This situation was described as existing for the case of the cockpit-control application, where a key-word vocabulary of only 25-30 words is required. Their experimental system uses a set of special-purpose pre-processor hardware to derive phonetic feature data from the speech waveform, a small digital processor (based on the LSI-11 unit) which operates on that data, and a standard alpha-numeric display to provide feedback and cuing for the user.

The choice of a basic set of features is a critical step in the design of any pattern recognition system. For operation with continuous speech, where word boundaries may be very poorly defined within the signal waveform, the *word* is obviously a poor choice as the basic feature. It is less obvious that the standard set of phonemes is also a poor choice. Beside being language-dependent (which is not a serious shortcoming in many applications), the occurrence of phonemes can be context-dependent; this can lead to problems in the case of continuous speech. For example, with a sloppy transition between two words, the first of which ends in a vowel and the second of which begins with a different vowel, the resulting sound can be the formation of a "phantom" phoneme, a diphthong which doesn't correspond to a sound in either word. The opposite situation, i.e., a lost phoneme, can occur between two words that share the same phoneme at their junction (e.g., "six-seven-nine" loses an "s" phoneme between the first two words and an "n" between the next two). Since the system must allow an almost unlimited vocabulary of irrelevant conversational words and other sounds (yawns, hiccups and extraneous interjections), the choice of a basic set of features for pattern recognition was made so as to avoid that kind of expected ambiguity.

Their rejection of the standard set of phonemes led to the choice of a somewhat more basic set of phonic features, units of speech that contribute to the formation of phonemes. Some of these features are also phonemes in their own right.

Analog processing methods were chosen to derive the short-time spectral data necessary to specify the phonetic features. (The analyzer employs correlation techniques implemented with analog shift registers and analog multiplier chips.) They consider that choice critical in their attempt to achieve real-time capability while keeping the cost of the system within reason and within the constraint that their experimental equipment use only generally available devices. At the interface between the pre-processor hardware and the digital processor, the line rate is approximately 2000 bits per second with a 10 ms resolution of the data in the time domain.

The first step in the processing procedure generates a sequence of conditional classifications (and durations) of phonetic features. Through a "sliding window", the next step compares a group of incoming features with many short groups of features which have been stored in a Short-Term Memory, each of which is labeled with an identifier. This reference set is built up through the combination of an initial training operation (discussed later) and an interactive error-correcting mode which goes on during the system operation. This memory holds representations of a wide variety of speech sounds, most of which are word fragments or short words, but it also includes a number of irrelevant sounds.

A separate storage unit, the Vocabulary Memory, is made up of a set of specifications on the allowable durations and sequences of phonic features that correspond to each key word. Comparison Logic operates on the inputs from the Short-Term Memory, the still somewhat ambiguous outputs from the phonetic feature classifier, and data called from the vocabulary listings. Its analysis procedures are governed by protocols laid down by a Directorate module. These protocols are context dependent: they may specify particular subsets of vocabulary or

they may specify the closeness of match required in a string of phonetic features. Pay pointed out that, in the latter case, in a context where a number is expected, *tree* and *three* are equivalent, as are *sex, socks, Sikhs*, and *six*.)

The Comparison Logic does exhaustive searches (within the specified protocols) and provides sets of conjectures to an Answer Storage unit. Each conjecture is accompanied by a quantitative estimate of reliability. A Decision Logic unit, also under control of the Directorate, provides resolution of the ambiguities that may exist in the Answer Storage. That resolution may be in the form of an unambiguous decision, a suggestion for a "second try" on the stored data, or a request for interaction with the user through the video display. (As an example of such an interaction, when, during the demonstration that I witnessed involving cockpit controls, in the context of a command to assume an azimuth heading, the number 410 was spoken, the display responded with, "50 degrees?").

The Directorate can, in addition to exercising the controls previously described, apply elementary grammatical and syntactical rules where they are appropriate. It can also modify the processing protocols in accordance with responses that it gets from interactions with the user. For example, if in the process of such interaction, it displays a decision which the user rejects as incorrect, the Decision Logic will be directed to reconsider its decision in light of the fact that its previous response was wrong. This type of error correction, by variation of logical operations, is a powerful tactic in accommodating to peculiarities of the user.

It is in this respect, i.e., accommodating to a large population, that the system has its greatest attraction. Pay indicates that their experimental system has worked well with a variety of English dialects spoken by young and old users of both sexes. The critical aspect of these tests was that the great bulk of individual users were *not* obligated to participate in training the system. Their individual speech peculiarities were accommodated by the single vocabulary "template" per word that was generated by a small set of trainers.

Pay's group is now in the process of refining their algorithms, of preparing to study the operation of their system in the presence of an undulating background noise (at the instigation of a prospective user in the Ministry of Defence), and of transferring their technology and experience to the members of a newly-formed "Speech Club".

That club is made up of representatives from nine British industrial organizations. The annual "dues" of £8,000 ($19,000) per organization helps to support the NPL work, but the major support is from NPL's governing agency, the Department of Industry. During these times of industrial pessimism in Britain, ideas of the sort being generated and tested by Pay's group are needed to bolster Britain's high technology morale. The group's research work seems to be a "winner"; it is now left to the club members to tailor the systems to specific applications and to evaluate the systems in field trials. (Philip Fire)

COMPUTER SCIENCES

EMMA (ITALY)

EMMA is an acronym for Elaboratore Multi Mini Associativo (Multi Mini Associative Processor). The "lady" was developed by ELSAG s.p.a. (Elettronica San Giorgio) of Genoa, Italy.

The architecture of EMMA is said to allow the implementation of different configurations that match the requirements of specific applications with flexibility. The system includes hardware and software modules connected in tree-like structures and offers a theoretically unlimited expansion of computing power. EMMA can be considered as a "multiple cluster hierarchical system." It is characterized by a hierarchical structure having several buses, each defining a cluster (family) formed by processors and memories. Each processor is called an associative unit (AU). Such an architecture makes it possible to achieve parallelism with relatively simple interconnection schemes.

Fifteen to twenty EMMA systems have been fielded to date, each consisting of 3-5 families. This gives a total of 45-100 AUs. A total of over 1,000 AUs have been delivered mainly for post office and pattern recognition applications.

System Architecture

EMMA architecture is of multi-instruction and multi-data stream type. Its basic building blocks are a set of processors, memory modules and system buses. Its special purpose application configurations are instrumented through the software operating system rather than physical hardware interconnections.

The basic system module of EMMA is the AU. It is a 16-bit minicomputer. The central processing unit (CPU) of AU executes the conventional arithmetic

and logic instructions at approximately 1.2 million instructions per second. In addition to the standard minicomputer instructions, an AU can access memory in an associative manner, speed up searches, compare bit strings, and determine Hamming distances. Each AU can have an associative memory module from 1 to 32K words and is connected to the CPU and the common bus. This author questions the marginal utility of the associative aspect of AU. However, a 1K associative memory is a nice hardware 'function box' to have available in a mini.

The common bus operates in a DMA (direct memory access) mode. For EMMA, complete addressing transparency is not needed. The main parameter for each application is the data transmission rate. For a given set of hardware components, when the overhead generated by conflicting bus requests is lowered—the effective bus transmission rate is higher. EMMA's bus is optimized for block transfers, to a maximum speed of 1 million words per second.

The bus is controlled by a data exchange coordinator (DEC). Processors normally access their local memory. If there is a requirement for a processor to exchange data with another processor, it issues a request to DEC. After all higher priority requests have been served, DEC obtains from the requesting AU the parameters relevant to the transfer (such as source, destination, pointers, length of block) and coordinates the DMA transfer. When the transfer is completed, DEC signals all processors to terminate.

A set of AUs connected through a bus forms a family. A family can have a maximum of 128 AUs. However, the family size is limited by the bus saturation. Therefore, if an application is both computation and data transfer bound the system can be configured as a set of interconnecting families using independent buses controlled by a MONITOR. The MONITOR is another AU that is used to interface standard peripherals and to run the system fault diagnosis procedures. This hierarchical approach represents a pragmatic way to parallel processing which is not widely accepted in the US. Special peripheral units can be interfaced via the input/output (I/O) channels of the AUs, or directly through the bus.

Operating System (OS)

EMMA OS is in levels which reflect the hardware hierarchy. There are five "extended machine" user levels:

Level Ø - minicomputer OS kernel/processor management
Level 1 - inter-processor communication management
Level 2 - inter-family communication management (IFC)
Level 3 - task assignment on AUs
Level 4 - monitoring and reconfiguration facilities.

Level Ø is the AU "uni-processor" kernel executive. Levels 1 and 2 manage communications within a family and among families. They supply synchronization primitives and allow communications with the minicomputer used as MONITOR. These two levels form the core of a distributed operating system residing in each AU. Level 3 resides in the MONITOR. It activates and distributes processes among the AUs. Level 4 has program modules residing in the MONITOR and modules distributed among the AUs. They can be used for fault-diagnosis and for system reconfiguration. There is no evidence that level-4 development has been completed for EMMA.

Process Synchronization

Each of EMMA's AUs has only one associated process, which executes a procedure called COROUTINE. A COROUTINE consists of a set of program modules including the code and its distinct input output messages. The set of COROUTINES related to a family of AUs is called a PROCESS. Considering processes and processors to be interchangeable simplifies EMMA's primitives. Only one synchronization structure is required. Synchronization primitives are event driven. Only significant events are permitted to send or to receive.

Two synchronization primitives, WAIT and AWAKE, are defined in EMMA. Their syntax is the following:

<PRIMITIVES> :: = <AWAKE>|<WAIT>

<AWAKE>::= awake name

<WAIT> :: = <LIST> name | name

where name is the name of a message. Several conditions may be "ANDed" by WAIT. There is no common data structure (apart from message buffers). A process which operates on a non-local data structure must request another process to supply it. Mutual exclusion problems arise only in connection with the handling of message buffers. Conflicts are resolved by the bus controller during the block transfer of data. This is natural for the DMA bus.

Planned Concurrent PASCAL

For resource allocation, a system configuration language is planned. The language is largely based on concurrent PASCAL to which it adds a data type ("processor") and two attributes ("resident", "alternate").

The system configuration language allows one to supply to the operating system the parameters necessary for task assignment, memory allocation, message generation and reconfiguration alternatives.

It offers also some structured programming constructs such as IF . . . THEN . . . . ELSE and WHILE . . . DO.

The compiler for the system configuration language is intended to function as an assembler preprocessor. This "mixed" solution is due to lack of efficient means for the definition in high-level language procedures with specific real-time requirements. The status of the language is unclear. All EMMA applications are now programmed in assembler code.

Two Application Systems

(1) SARI

Sistema Automatico di Riconoscimento Indirizzi (SARI) was originally developed for the Italian Postal Administration. It is capable of processing over 50,000 mail items per hour for typed or hand-printed addresses (ZIP code, city, district name or initials). A prototype SARI has been in operation since July 1976 in an Italian Post Office. SARI systems are presently operational in several primary centers of the Italian Postal Administration. Each system is an EMMA with 45 AUs, subdivided into 3 families. The letter from a feeder is scanned by an optical reading head and digitized input data are analyzed by a set of EMMA processors using software that perform noise reduction, line searching, line selection, word segmentation, type searching, and type recognition. Proper address matching is accomplished by using the special associative instruction in AU.

Recently SARI was expanded for the French Postal Administration: an EMMA system is being used with 65 AUs, subdivided into 4 families. Two sets of programs are executed on the system: the first set is identical to that of SARI for the Italian Postal Administration; the second set performs also the recognition of city district and street names. The system is operational. Extensive testing has been successfully completed at the French Postal Adminstration Center in Arcueil (Paris). A license for building 40 SARI systems has been granted to Thomson-CSF of France. (A SARI system also is being installed in Philadelphia for evaluation by the US Postal Service.)

(2) MAORS

Multi-Application Optical Recognition System (MAORS) performs two functions:

(a) reading microfilm rolls containing the image of telephone counter panels (10 x 10 grid) at the speed of 2,000,000 frames/hour;

(b) reading two lines of numeric characters in credit certificates, at the speed of 60,000 certificates/hour.

An EMMA system is used with 50 AUs subdivided into 3 families. Film quality is poor and the recognition of useful information in a cluttered environment (including counter frames, reference numbers, sealing wires, etc.) is rather difficult. The following processes are performed by EMMA: image input, label identification, identification of images of single counters, segmentation and normalization, and measurement of the distances from the image digit archetypes. A MAORS system has been accepted by Italian Telecommunications for testing.

There are other application systems in development such as speech recognition and the bubble chamber application. However, lack of multiplication prowess in AU limits its utility in more arithmetic-oriented applications.

What's In A Name?

Let's reexamine the name EMMA. The system probably is not elaborate enough according to the US computer science community; the family hierarchy and block DMA bus represent a pragmatic and simple way to field an operational system. In engineering, simplicity implies elegance. ELSAG engineers admitted associative memory is not cost-effective for all applications considered. It is heartening to learn that only an associative search instruction has been implemented with sequential hardware.

The operating system is definitely not ambitious enough for software gurus. It works because of the sensible synchronization approach in a kernel executive with restricted message-passing facilities. Indeed it is special purpose, but it is a working multi-processing system. Perhaps profit motivation of the private firm, ELSAG, with limited resources, which force them to operate efficiently is the main reason for EMMA's success. In the US computer science community, it has been customary to change names of research topics to enable the same R&D programs to continue with more ambitious objectives. We witnessed Multi-Processing, Parallel Processing, Associative Processing, Network Processing and now, Distributed Processing. Two generations of computer architects

have been confronted by the same set of basic problems. The community awaits the arrival of someone ingenuous enough to venture "The Emperor has no clothes".

Despite all "buzz words" in EMMA, it is not claimed to be a panacea to multiprocessing. If the name of EMMA is changed to lower case letters for lesser computer science fiction, the reduced Italian lady *emma* is still very charming! (Y.S. Wu)

EDUCATION

ACADEMIC TITLES AND DEGREES AT ITALIAN UNIVERSITIES: WHAT'S IN A TITLE?—REVISITED

The situation in Italian universities with respect to academic titles and graduate degrees has been described in a number of *ESN* articles over the years. A particularly thorough discussion, entitled "What's In a Title?" was presented in *ESN* 30-7:303 (1976). At that time, no Italian PhD-equivalent program existed; none exists today either, but there is a change in the wind. In July 1980, a comprehensive law was passed by the Italian Parliament which sets up a significant reorganization of the university system (especially as it relates to scientific researchers) and it also establishes the *Dottori di Ricerca* degree program, to be analogous to the PhD or DSc programs in American universities. The law's impact on the university education system and the academic research environment has yet to be felt significantly because many of the details of implementation are awaiting definition by officials in the Ministry of Education.

My first exposure to the fact that the new law existed came about in the form of an apology for a missed appointment. The head of the department I was visiting at one of Italy's universities explained that one of his staff members whom I was scheduled to meet that day was taking a written examination for promotion from the nebulous status of reseacher to the formal rank of assistant professor. He described the examination as part of the *old* procedure for such promotions. The situation was a bit of a farce, he admitted: it was described officially as a competitive exam (competitive on the local level) and, as specified, considerable care was to be taken so that personal bias did not enter into the grading process. Precautions included coding each exam answer booklet with a number; the numbers were associated with the names of the competitors on a list which was kept secret from the (local) evaluators. The fact that this was a strictly local "competition" and that only one candidate was involved reduced the whole procedure to a mere formality. He indicated that the "new" procedure would be better—without specifying what the new procedure was to be. It was Assistant Professor Maurizio Longo at another university, the University of Naples, who took the trouble to provide me with an English translation of many features of the new law. A follow-up discussion with Guiseppe Xausa at the Italian Institute of Culture in London provided additional information on the subject.

With respect to the PhD-like program, the degree is only to be awarded in the "scientific" disciplines (but my efforts to get a working definition of "science" in this context have not yet been rewarded). The program of courses to be given will last at least 3 years following the first (MS-like) degree. In Rome, the Ministry of Education is empowered to control this program by specifying, on an *annual* basis, which universities are to be permitted to offer the new degree, how many such degrees each university may confer, and how many holders of the title each university may appoint to its own staff.

The law does not specify the content of the new degree program, but in sections which deal with the reorganization of the universities, a new (to Italy) entity is described which will have that responsibility. In the existing organization, "institutes" have the responsibility to organize the courses and to specify the research requirements leading to the degrees that are granted. Those institutes will continue to carry out those tasks for the "first" degrees, but they will now be brought into a "department" structure. Advanced courses and research associated with the new degree will be organized at the department level. (At this level, it all seems familiar; but, at a subdepartment level, the authority to organize MS-like degree programs becomes the different, Italian-style approach in the new system.)

The law also changes the academic staff system. For example, the rank of assistant professor is to be abolished, to be replaced by that of associate professor which does not exist in the present system. At first hearing, this change seemed insignificant to me—just a change in wording—but Longo explained that that was not the case. Approximately 15,000 positions with rank of associate professor will initially be filled from the existing group of assistant professors and lecturers, all of whom had considered themselves tenured.

Nationwide evaluations will be held once each year for the next 3 years. The evaluation will be based upon the candidate's record as an author and reputation as a teacher. Two chances are given; if, after the second application, the appointment to associate professor is not granted, the individual will not be allowed to continue as a member of the university's teaching staff! Suffice to say, some anxiety exists.

Full professors, especially the 5,000 additional positions established by the new law, are also to be chosen by a nationwide evaluation/selection procedure. The only basic difference in the evaluation criteria, compared to that for associate professor, is that teaching ability is *not* indicated explicitly as relevant; only the publication record is specified. Lastly, as regards professional staffing, the position of researcher is to be formalized, with tenure provided after a 3-year period of probation. Presently, the position exists functionally but not formally, and only on an insecure, short-term contract or fellowship basis.

Nationwide, no more than 5 percent of the full professors can be "foreigners" and approval in each case for appointment of a foreigner must be obtained from the Ministry. Visiting professors (called "Professors on Contract") can be appointed for at most one academic year at a time; their contracts cannot be renewed at the same university more than twice in 5 years.

The salary levels for visiting professors are not specified in the law, but salaries for the permanent academic and research staff are specified relative to certain outside salary levels. In particular, researchers' salaries are set at 5 percent above those for high-school teachers. Currently, this formula provides them with somewhat less than $10,000/year. A professor's basic salary is set according to a prescribed schedule related to the rate set for the government's highest employee category (called Level A). The schedule, i.e., ratio to Level A salary, is pegged in a strictly objective manner to the professorial category (full or associate), the academic load (full- or part-time) and the number of years spent on the academic staff. In addition, professors are given a special grant according to a similar schedule. Taking all of this into account, a full-time associate professor just starting out now has an after-tax income of about $15,000/year, while a full-time full professor receives about twice that amount if he has been teaching for about 15 years.

One crucial feature of the new system, especially during the transition period when many thousands of evaluations are to be made, is the process of selecting the evaluators. As noted previously, the plan for selecting the professors is to have national competitions within groups of disciplines. In the case of the full-professor category, each group (e.g., electrical engineering and physics may be two groups of disciplines) will have a national selection committee of 5 members. (The committees for the associate-professor category may be larger.) Each committee will be formed by a 2-step procedure: 15 professors will be designated by random selection from the nationwide set of all professors in each group of disciplines. Then those 15 will elect 5 among themselves to be the selection/evaluation committee for their group.

The law also includes other provisions relating to allocation of research funds within and between universities, the participation by professors on contracts with outside agencies and/or companies, and the relationships between administrative, curriculum, and research councils at the local and national levels.

Italy appears to have reacted to both internal pressures and external criticism in this attempt to recast its university-based education and research programs. The transition period ahead promises to be a time of trial and (let us hope, only a few if any) errors. (Philip Fire)

ENGINEERING

FROM ANTENNAS TO ACOUSTIC MICROSCOPES AT LONDON'S UNIVERSITY COLLEGE

The Electronic and Electrical Engineering Department of the University College London (UCL) was described in these notes several years ago by T.K. Cheng (*ESN* 30-7:305 [1976]). He traced its beginning to the first department head, Prof. J.A. Fleming, who invented the thermionic tube in 1906. During Cheng's visit the department head was Prof. A.L. Cullen who has now retired to the position of research professor and senior research fellow. The department, with an academic staff of 20, is under Prof. E.A. Ash. There are about 130 students in the 3-year undergraduate course and a further 50 research students (MSc, PhD). UCL has a total of some 5,000 students. Ash has divided the research work into 2 groups. He himself looks after the

first group, Physical Electronics; the second group, Systems, is headed by Prof. D.E.N. Davies, with reader (associate professor) John R. Forrest being deputy.

Davies discussed his research work on circular apertures. It originated with a VHF (200 to 400 MHz) communications receiving antenna, sponsored by the British Ministry of Defence. The antenna had a null that could be steered to reject an interfering signal. It consisted of a simple, circular array containing just 4, equally-spaced elements. Two outputs were obtained from the antenna: firstly, an output consisting of the in-phase summation of all 4 elements and secondly, an output consisting of the summation of the 4 elements but with a linear phase progression being applied from element to element, amounting to 360° around the circle (0°, 90°, 180°, 270°). With small spacings it can be seen that both outputs give an approximate omnidirectional radiation pattern phase that is independent of angle, whereas the second pattern has a progressive change in phase with angle. The 2 outputs were adjusted to be equal in amplitude and added. The resulting pattern now has a null in direction that depends on the relative phase of the 2 outputs and which can be rotated with a phase shifter in one of the outputs. The principle applies even better to circular arrays with many elements; a 16-element array was built and modeled with support from ASWE (Admiralty Surface Weapons Establishment). It should be noted that circular arrays of this type have the attractive property of fitting around circular structures like masts. It turns out that proper phase progression for such an array can be obtained directly from a "Bulter Feed" which is a hybrid matrix used for multiple-beam formation.

The response of the antenna was noted to be omnidirectional and therefore a reduction in size should not affect the pattern shape. However, if the diameter of the circle becomes very small, then super-directive effects become apparent for the mode having the progressive phase excitation. These effects may be regarded as the presence of highly-reactive mismatches due to mutual coupling. Matching under those conditions would result in both efficiency and bandwidth being reduced. Nevertheless, with a 4-element array on a diameter of 0.04 λ, a 20% bandwidth was obtained with resistive matching at 150 MHz, with a resulting gain that was about 5 dB below that of a dipole. In spite of this reduction in gain, the capability of suppressing an undesired signal by pointing the null would, in most cases, lead to an improved signal-to-noise ratio. In a further study sponsored by both Racal Antennas Ltd. and the Science Research Council (SRC), an adaptive-null steering system was investigated. It assumed that the interfering, undesired signal was much greater than the desired signal. For future systems, Davies suggested multiple operators, each with the capability of choosing at his frequency either an omni-pattern or a pattern with an adaptive null or, lastly, a pattern with a null that can be manually pointed.

Dr. M.S. Smith, who is lecturer in the Systems Group, described to me microstrip Rotman lenses that have been developed. These lenses follow the Abbe sine condition and have wide-angle scanning properties. The work in this area is supported by the SRC. Another microwave scanning system was developed using a shaped wire grid. The scheme dates back to a 1947 patent by Harley Iams, who was then at RCA. If a grid of parallel wires inclined at 45° to the vertical were to be impressed on a vertical cylindrical radome, and if one then viewed this from the outside, then one would find that the front surface had wires with an inclination that was opposite to that of the wires on the back surface. The wire grating could therefore allow one polarization to pass through at the front, but reflect that same polarization at the back, with the circular shape causing approximate focusing at about half the radius. In the actual embodiment the radome is not cylindrical, but shaped so as to add focusing in the vertical plane. This construction allows scanning over 360° in the horizontal plane with a focusing locus of about half the diameter of the (deformed) cylinder. The feed can be rotated in an arc to scan the beam or be rotated or switched electronically. In the latter case, one finds again a circular structure. Smith and his colleagues are optimizing a feed system for good side-lobe performance. The work is sponsored by the SRC and Racal Decca Ltd.

J.G. Schoenenberger described the active phased array radar development program. The original work, under the guidance of Forrest, was supported by the US Air Force, Plessey Company Ltd., ASWE, and others. It culminated in a report published in October 1979, in which many of the options of an active solid state X-band phased-array radar were examined and a specific approach, believed to be low-cost was recommended. It led to the development of an 8-module experimental array. Each module had a solid-state

transmitter section formed by a pulsed Gunn diode oscillator, varactor tuned, and controlled by a heterodyne phase-locked loop. Phase shifting for beam steering was therefore done conveniently at IF. The module also contained the receiver where the signal was immediately downconverted, again with phase shifting taking place at IF. The radiating elements were formed by printed dipoles.

At this time, the solid state phased array work is continuing along the same lines, but aimed at the development of an S-band module with ASWF sponsorship. The transmitter in the module is a class-C operated power transistor used with a high-duty cycle. A large array is now being planned at an estimated large quantity production cost of $700/module. The overall engineering will be at ASWE, but the basic model design is in Forrest's group.

Optical control of solid state oscillators is also being investigated by Forrest's team and was described by Schoenenberger. A laser beam is modulated at microwave frequencies or their subharmonics and brought through a fiber to give a direct optical input to an otherwise free-running Impatt oscillator. An experimental model had a 9 GHz output and was locked to a control modulated at 3 GHz. Modulation was achieved by direct microwave interaction with a GaAlAs solid state laser. A tuning range of 10 MHz was obtained and much wider ranges are believed possible. At 2.3 GHz an FET oscillator was successfully locked in a similar way by an optical signal modulated this time at the fundamental frequency. A drastic reduction in oscillator noise occurred upon locking. The scheme is believed to have potential for phased array applications where the RF distribution network of the transmitter might be replaced by optical fibers. This work is supported by the SRC and others.

For many years the radar community has talked about using somebody else's fortuitous transmission for a passive, nondetectable radar. Schoenenberger described his work with just such a scheme which has actually been implemented. The transmitter is the 600 MHz Civil Air Traffic Control Radar at London's Heathrow Airport which is about 15 miles away. It transmits a 4 μsec pulse with a PRF of 400 and has a 2° horizontal by 20° vertical rotating beam. The only link to the transmitter is the reception of the direct signal and the target echo. The receiving antenna is a simple dipole on the roof of UCL. Detection ranges of 40 nautical miles are typically obtained with a DC 10 as target. The main problem concerns the display which is distorted due to the bistatic geometry. A real time fast microprocessor has been constructed to correct the display and is being evaluated. It uses readily available cheap components from the TV band. Incoherent MTI (moving target indicator) is available, but an effort is being made to process coherently and to obtain a reference for that, which is difficult, since the direct signal is lost much of the time due to the distant antenna's rotation. Other aspects being studied are the formation of multiple beams, sidelobe suppression, and null-steering.

A group of six people under Ash is working on acoustic microscopy using frequencies from a few MHz to the GHz region. Collin Petts from this group described some of the work which is variously supported by government and other agencies. Studies of tissue were carried out in cooperation with the Royal Marsden Hospital. In its simplest form, the microscope consists of a transducer transmitting through a short focal length lens, aligned with a similar setup for receiving. There is a coupling medium, frequently water, and a sample is mechanically scanned through the focus in a raster with a stepping motor. Amplitude, and at the lower frequencies also phase, of the transmitted signal is recorded. The focal spot size determines the resolution and is about one wavelength with an F=1 system (F is the ratio of focal length to aperture size). The wavelength in water at, for example, 1 GHz, is 1.5 μm. The main difficulty is due to the very high attenuation that occurs in the coupling fluid.

Early work resulted in microscopes using 50 to 150 MHz which were and still are being used to examine tissue and industrial samples with resolutions of typically 10 μm. It takes about 1 hour of scanning to produce a picture. Petts showed interesting pictures of an onion skin and how it changed with a change in salinity of the medium. The frequency was then increased successfully to 1 GHz, but a further increase to 1.5 GHz gave rise to some alignment difficulties which were overcome by making the receiver nonfocusing. A reflection-type microscope has been built with a combined transmitter-receiver and using short pulses (50 nsecs). Additional sample peculiarities were found by moving the sample back and forth so that the focus also came to lie within the material. The aim is to establish a library of various material characteristics.

Resolution is limited by the wavelength in the coupling medium and therefore increases linearly with frequency. Attenuation, on the other hand, is proportional to the square of the frequency and therefore sets an upper frequency limit. Higher resolutions can be obtained by better choices of the coupling medium. Liquid metals could be used, they have lower attenuation, but give a longer wavelength than water. Cryogenic liquids could also be used (and are used by researchers at Stanford), for example, liquid helium can give significantly better resolution but requires the sample to be cooled. The approach chosen at UCL is to use gases, particularly argon. The attenuation is about 100 times higher than that of water, but can be reduced to be about equal to that of water with the application of high pressure. The wavelength is about 5 times shorter than it is in water (velocity is 1/5th). A 45 MHz acoustic microscope was built to show feasibility, using argon at 30 atmospheres of pressure, and a resolution of 7 μm was obtained. A 750 MHz system with 40 atmospheres of pressure has been built and is presently being evaluated. It may use xenon as medium which gives a further reduction in wavelength by a factor of 2. A still more advanced system has been designed and is being built for 2.5 GHz with 250 atmospheres of pressure. It is expected to give a resolution better than about 0.1 μm. This should make UCL a leader in the race for higher acoustic resolution.

Cheng finished his description of UCL by commenting on the variety and the high quality of work. This is clearly still true today. (T.C. Cheston)

SONAR & SIGNAL PROCESSING AT LOUGHBOROUGH

Originally a technical college, England's Loughborough University of Technology (LUT) in Leicestershire achieved university status about 12 years ago. It was at that time that Prof. J.W.R. Griffiths joined LUT as head of the Department of Electronic and Electrical Engineering (EEE). Previously, he had been associated with Prof. Tucker, well known for his work in the field of sonar and signal processing, and worked with him initially at a scientific naval establishment and later at the University of Birmingham. The University of Birmingham team is today still very strong in these areas under the leadership of Prof. D.J. Creasy, but was for a long time under Tucker the very center for academic work on sonar and signal processing. Many of Tucker's team achieved leading positions in the UK, Griffiths, for example, and also Prof. H.O. Berktay at Bath University, Prof. D.E.N. Davies at London's University College, and Dr. A.W. Rudge, who is managing director of ERA Technology Ltd.

Griffiths built up the Department of EEE until today it has about 400 undergraduates, 100 to 120 postgraduates, and an academic staff of about 40. The university as a whole caters to some 5,500 students. Last year the department had 2,500 applicants, so it can afford to be highly selective in its choice of students. Griffiths had become deputy vice-chancellor, which entailed much administrative work, but this year he is on sabbatical leave and will spend some time at the Indian Institute of Technology in New Delhi, where he has given some courses in the past. He will then visit the US where he is scheduled to give a number of seminars and discuss adaptive beam forming, which has become a subject of considerable interest in the radar and sonar fields. In the meantime, Griffiths has handed over leadership of the department to Prof. I.R. Smith and intends to be a research professor upon his return, a position that has no extraneous administrative duties.

While the research activities of the department also include such areas as microelectronics, electric-power-related electronics, and machinery control, Griffiths' main areas of interest are research efforts in sonar, signal processing, and communications. In the field of sonar, Griffiths and LUT have a long-standing association with sector scanning sonar systems. Several systems have actually been developed and built at the university. All systems use within-pulse scanning techniques and examine a relatively narrow sector in either the vertical or horizontal plane. The sonars are used to look for and examine fish and schools of fish and for mapping the bottom. The equipment, which was built by LUT to operate at frequencies of 300, 150, and 75 KHz, includes the transmitter power supply which consists of 2 modules giving a peak power of 20 kW. The development work, which Griffiths carried out in cooperation with the microelectronics group, included a search for pressure-resistant components that could be used at depths without protection.

Transmitting and receiving arrays for the sonars were developed in the transducer laboratory of the department. The transmitter beam is wide to provide a searchlight illumination of the sector that is being scanned by the receiver.

High peak transmitter (20 kW) is necessary and would normally lead to cavitation if the small aperture that corresponds to the wide transmitter beam were used. To overcome this problem, the transmitting aperture is made much larger than normally required, but to avoid the formation of narrow beams, it is formed by transducers that are placed on the arc of a circle and that are energized in phase. The equivalent plane aperture, therefore, has a spherical phase front which generates approximately a wide, square beam. In this way more transmitter power becomes available without cavitation occurring and the transmitter beam has a more efficient (square) shape. In one experimental configuration, an oversized planar aperture was used with a lens in front of it to achieve the same spherical phase front. Some of the sonars were evaluated in conjunction with The Fisheries, which is a laboratory in Lowestoft, Suffolk, operated by the Ministry of Agriculture, Fisheries, and Food.

At this time the main efforts in further developments of the sonar are in the area of display. The development of a scan converter is a project being carried out in conjunction with microprocessor studies. The conversion is from a Cartesian display to a polar display corresponding to the actual geometry. Use is being made of commercially available, inexpensive, graphical display systems that are based on standard television raster scans and have a digital frame store. Color is now being added as a further dimension to the display, or rather pseudo-color, since there is no natural link between colors and what they represent. Color is used primarily to indicate the target strength but also to denote various processed data, and its choice is arbitrary. Griffiths emphasized that it is still not known how to use color best, nor how much advantage the operator can gain through its use. The color display system that is being developed has flexible options and has not yet been evaluated. It still remains to be shown whether or not it will bring an improvement in performance.

A sector scanning sonar is used to detect and track fish or schools of fish, but it is extremely difficult not only to recognize the type of fish from the sonar signal, but also to make a good estimate of the abundance of fish. A knowledge of the abundance is of considerable importance in these days of overfishing, and could lead to legislation for the control of fishing, even if such control is difficult to impose. Griffiths is developing a model that predicts the abundance of fish from the data of a sector scan sonar system. The model is relatively simple and assumes the fish to be a single point scatterer that reflects the transmitted pulse after a delay depending on its radial distance and an amplitude, which is determined by the target size and orientation. Abundance estimates are then made just from the echo signal strength and its variation with time (range). One way of conducting the experiment is to look down from a ship using a scanning sonar with a narrow beam. Some evidence had been obtained with this technique showing that fish sometimes are positioned on the circumference of a circle, rather than solidly filling the circle. At this time the work is being done by computer modeling with simulated targets against which the system's capabilities of making abundance estimates are evaluated. A next step is contemplated whereby the ship's motion is taken into account and deconvolved with the received signal. It is planned to test the abundance estimates with experiments carried out in conjunction with The Fisheries.

Griffiths, in collaboration with Dr. J.E. Hudson from his staff, is devoting a lot of attention to adaptive beam forming. This subject is of much interest for both sonar and radar systems and is aimed at perfecting the combination of the individual sensors in an adaptive way to enhance the desired signal and to suppress undesired signals such as those of intentional/unintentional jammers or noise sources. In its simplest form the system points a null towards an undesired signal. In general, the angular spectrum is required at every range. To achieve the desired response, the contributions from the individual receivers of the aperture are multiplied by complex weights before addition, with the restriction that the sum of the weights is unity to maximize the output. Derivation of the weights is difficult and involves the inversion of a matrix formed by the multiplication (correlation) of the outputs of each element with that of every other element. Various iterative techniques are investigated and some hardware is being built in an attempt to cut down on required computer time.

The research emphasis at LUT is likely to change with the change of the department head. Such change is even more likely to occur in the near future since three principal members of Griffiths' staff have left to take up appointments elsewhere. Griffiths' sabbatical is starting a new era at LUT.
(T.C. Cheston)

MATERIALS SCIENCE

DKI—DEUTSCHES KUNSTSTOFF INSTITUT

Darmstadt is a small, quiet city of baroque, renaissance, and modern architecture surrounded by the rolling woodlands of the Oberwald. Contained within the Darmstadt University of Technology, but not part of it, is the Deutsches Kunststoff Institut (DKI), an industry-sponsored organization for polymer research and development. It was organized in 1953 by the Forschungsgesellschaft Kunststoffe E.V. (FGK), an association representing 181 companies (and scientific organizations) involved in polymer synthesis and processing. Initially the DKI was formed to train engineers and scientists for the West-German polymer industry and to provide postgraduate research opportunities in polymer science and engineering. Today, its mission is more broadly based and includes the collection and dissemination of technical information on polymeric materials. The DKI receives 50% of its funding from sponsoring industries and 50% from the government for contract research. A sponsoring company may request research at DKI through the FGK. The DKI staff decides whether to undertake the work on the basis of its general interest to the sponsoring membership. If the DKI decides to accept the proposal, the work is done using funds from the fees paid by the member industries. If DKI declines to do the work as part of their general R&D program, the company can still ask to contract the work at DKI, but must provide full support. All research results are available to all member organizations, whether the research is funded by membership fees, the government, or individual companies. Research results are published in the open literature after a short delay to allow industrial exploitation. The work is almost entirely basic research, first, because it must meet university standards for graduate and postgraduate dissertation investigations, and secondly, because it addresses basic problems common to the plastics industry as a whole which are not critical enough for one company to take on by itself.

The director of DKI is Prof. Dr. D. Braun, who holds a chair in macromolecular physics at the university. Although DKI has no organizational connection with the university, many of the staff hold teaching positions and most of the DKI research students are enrolled in the university.

There are four departments at DKI: Physics, Chemistry, Technology, and Documentation. The emphasis in the Physics Department is on polymer morphology (mostly crystalline), the relation between morphology and mechanical properties, and how morphology can be altered to obtain specific properties. They are primarily engaged in theoretical and experimental studies on the compatibility of polymer blends; their properties as melts, their crystallization behavior, and their mechanical properties. The approach is to investigate morphology using optical techniques to determine phase composition and distribution. The physics people are also studying the cross linking of polyethylene (PE) by ionizing radiation and investigating whether cross linking occurs in the crystals where the radiation absorption is the greatest or whether it occurs in the amorphous regions where chain mobility is greatest. They do not believe the question is yet resolved and hope that their experiments will provide some answers. Finally, they are experimenting with thermoelectric relaxation. This phenomenon is observed by placing a solid polymer sample in a constant electric field above its glass-transition temperature and then cooling it in liquid nitrogen. An induced current is generated in the sample as it slowly heats. Surges in current occur as the polymer passes through the temperature range of specific molecular relaxations. These relaxation currents are observed even in polyethylene because of polar end groups and polar impurities.

The chemical department staff is involved in some limited polymer synthesis. However, they feel that it is unlikely that any new, significant polymers remain to be discovered. Even if they were, it would be too expensive to develop them into economically viable materials. In the present market it would be impossible to amortize new plant facilities and small-scale production is generally uneconomical. Instead, the majority of the effort at DKI and around the world is given to polymer blends, block copolymers, and multiphase polymers. Specifically, the people at DKI are working on the kinetics of copolymerization, methods for characterizing copolymers, and tailoring the chemistry to specific properties. The work on multiphase materials is primarily on stabilizing acrylonitrile-butadiene-styrene (ABS) against ultraviolet (UV) degradation. They are trying inorganic fillers as stabilizers, especially carbon black. However, they find that the fillers

degrade the mechanical strength, and so are attempting to graft the polymer to the filler particles in order to develop better compatibility.

The major effort of the Chemical Department, and one of the largest programs at DKI, is the work on polyvinyl chloride (PVC). The work includes UV stabilization, processing, and polymerization chemistry. They are trying to understand the mechanism of UV degradation and suspect it may involve UV adsorption by adventitious double bonds including carbonyl groups in the polymer. They would like to know where these unsaturated groups come from and whether the concentration can be correlated with the rate of degradation. In the processing of PVC they find that additives e.g., plasticizers, pigments, or stabilizers, diffuse to the surface and leave undesirable coatings on the processing equipment.

Other work in the Chemistry Department includes the cocondensation of phenolic and amine resins. It is questionable whether condensation actually occurs or whether there is simply a nonreactive mixing of the polymers. The DKI people think that mixing predominates. They are also looking for new azo-type free-radical polymerization initiators. The commonly used azobutyl nitrile degrades to toxic products and the government may legislate against its use. The physical chemistry activity in the chemical group includes Kerr effort studies of molecular relaxation and some specific efforts in relating polymer morphology to mechanical properties. They have pioneered the study of solid polymers using the Kerr effect which involves changes in optical polarization in an electric field. By fluctuating the electric field strength they can study chain relaxation phenomena. They have been most successful investigating amorphous polymers like polymethylmethacylate. The technique is similar to dielectric measurements but has higher sensitivity to molecular motions. The work on morphology and mechanical strength is directed specifically at the effect of voids on mechanical properties and the effect of strain on chain orientation. Using small angle diffraction they observe the change in void size and population with cyclic loading and find a correlation between surface formation and strain energy input. The chain orientation work is being done on polyethylene terphthalate (PET). They have developed theoretical analyses for chain orientation as a function of the extent and rate of biaxial loading. Presently, the theory is being tested against experimental results. A special section of the DKI Chemistry Department is the plastics an analysis group. The analytical work that this service organization provides is essential since nearly 50% of the West German plastics companies have less than 20 people and are too small to do extensive, routine analysis.

The Technology Department at DKI is studying the thermal properties of polymers; the effect of thermal history on mechanical properties and heat capacity, and the thermal conductivity of insulating foams. In polymer processing the work is aimed at the type of flow exhibited by polymer melts containing short glass fiber reinforcement. One of their findings is that PVC melts exhibit wall slip (slug flow, the flow rate is nonzero at the pipe wall). They relate this phenomenon to the presence of the fibers. It is not due to surface roughness and in fact cutting grooves in the wall eliminates wall slip and the flow has the normal parabolic velocity profile. The significance of this observation is that the injection molding of PVC-fiber melts requires very different pressure and temperature conditions than the molding of polyethylene melts which have normal flow behavior. Also, slug flow will influence the fiber distribution and orientation in the molded part. The technology group is also investigating the wear, corrosion, and abrasion of polymer melts and solids on the metal components of processing equipment. They find that the corrosive action of filled polymers is greater than the reaction of the filler or the polymer taken alone. They are trying to investigate the uniformity of polymer mixing but find that there are no established methods to obtain quantitative results. Presently, they are using additives such as pigments or metal powder to determine how uniformly these additives are dispersed by different mixing procedures. Nondestructive evaluation (NDE) work in the Technology Department is largely devoted to the analysis of acoustic emission from specimens under stress. They are using this technique on fiber reinforced plastics (FRP) and on crystalline polymers. They can detect acoustic events associated with crystal reorientation. The FRP work is aimed at using acoustic emission to investigate the failure mechanisms of fiber-reinforced thermoplastics. They are working on styrene-acrylonitrile reinforced with polycarbonate fibers. From acoustic emission amplitude and energy distribution per acoustic event they are able to identify microdeformation events during tensile loading. Using electron microscopy they have been able to relate

acoustic emission to fiber pullout, fiber fracture, delamination, and massive failure.

The Documentation Department is a relatively new effort at DKI. It was created in 1973 as part of the FRG Government's effort to develop centers for the collection and collation of chemical information; DKI was designated as a center for plastics information. The department reviews over 200 periodicals from all over the world and abstracts nearly 50,000 articles and scientific papers yearly. The abstracts are stored on computer tape and punch cards according to subject area (thermoplastics, processing, etc.) and subtopic (polysiloxane, injection molding, etc.). Abstracts can be purchased according to subject area or subtopic, or a background search can be made on a specific class of polymers, their synthesis properties, and/or methods of processing. DKI publishes a monthly list of new abstracts. It is excellently crossreferenced so that an abstract about the processing of PVC, for example, is listed under processing and also under polymers.

The DKI provides considerable service to the German plastics industry; the training of scientists and engineers, basic research, and documentation. Its organization and function is in many ways similar to the Rubber and Plastics Research Association (*ESN* 34-4:183 [1980]) in the UK. The DKI is often compared to the Institut Kunststoff Verarbeitung (IKV) in Aachen, West Germany, but the resemblance is superficial. The IKV is devoted entirely to R&D on polymer processing (*ESN* 34-5:228 [1980]) whereas the work at DKI is more broadly based and more fundamental. In many ways DKI and IKV complement each other and together provide the West German plastics industry with a very considerable R&D capability. (Willard D. Bascom)

OCEAN SCIENCES

A FISH STORY FROM ICELAND

When you talk with an Icelander you usually find out that he is a social scientist by avocation. He would rather talk about Iceland's history, economics, politics, and social problems than about his vocation. Recently I interviewed a number of marine scientists in Iceland and often had trouble keeping them on the subject.

One of the people I spoke to, Mr. Jacob Jacobsson, deputy director and acting director of the governmental Marine Research Institute in Reykjavik, used the whole hour allotted to me to tell me a fish story. The moral of the story was that either man, with his highly sophisticated modern fishing gear, must be prevented from overfishing in the oceans, or fish stocks will simply disappear. (A single codfish can now be seen on sonar at a range of over 100 m.)

When Jacobsson joined the laboratory as a herring fisheries specialist, most of his efforts were exploratory. He was concerned with locating new stocks of fish and learning when and where migrating stocks of fish could be caught in the most efficient manner. The determination of migratory patterns was most important.

Most of the fishing activity in Iceland 25 years ago was centered around the Atlanto-Scandian herring which formed one of the largest stocks in the world. In 1950 the stock was estimated at 10,000,000 tons. By the early 1960s, as fishing technology became more efficient, income from this fishery made up 56% of Iceland's foreign exchange income from exports.

At the height of the fishing activities, in 1965, Jacobsson was a national hero. When the grateful owners of the fishing fleet found out that Jacobsson needed a new research ship, they passed the hat among themselves and raised enough money to build a ship to give to the laboratory. They were so anxious for Jacobsson's continued research that the vessel had to be built immediately. A suitable design had already been drawn up for a modern fishing vessel. With a few modifications it would suit the laboratory's needs. It was completed and put into operation in 1967.

Jacobsson's popularity was so great in the mid 60s that he rated a front-page heading in Iceland's leading newspaper. The headline stated that Jacobsson's salary was too low and should be doubled by the grateful nation.

No one at that time saw the dark clouds on the horizon. New, modern methods of locating schools of fish by improved sonar were based on advances in submarine search equipment. Schools of fish could be located easily and identified.

Indications of trouble appeared soon after Jacobsson's new vessel was put into operation. In 1968, signs of depletion of the major stocks of both migrating and local herring were first recognized. The herring were particularly vulnerable because of their schooling behavior. They always appeared in dense schools which were very easy to locate with the newest sonar fish finders and easy to catch from the larger improved vessels. By the early 1970s all stocks of herring available to the Icelandic fishing fleet were virtually depleted.

The laboratory, and in particular Jacobsson, then had to say unpopular things and to recommend curtailing the fishing efforts. The laboratory was able to persuade the government to place a ban on fishing for local stocks of herring around Iceland for the years 1972 to 1975. The result of this was that Jacobsson fell from grace with Iceland's fishermen.

The local stock was slowly rebuilt by carefully controlled harvesting until now it is able to sustain an annual take of 40,000 to 50,000 tons. A 3-month season has now been established. If the whole fleet of about 200 fishing boats were permitted to do so, they could bring in the total allowed catch in a week. This cannot be done because the processing plants ashore could not handle the catch in such a short period of time, and so it is necessary to spread the fishing out over the whole 3 months. Ideally 10 or at the most 20 vessels could work the whole season and economically bring in the whole catch. Instead, each of the 200 vessels works only a few days.

Because of the necessary restrictions that exist, the size of the fishing fleet should be reduced, but this is a very unpopular notion politically. In point of fact, the very opposite is happening and more boats are being built.

In contrast to the local stock of herring, the story of the originally much larger stock of Atlanto-Scandian herring is a different one. It is, or was, a migratory stock that could be preyed upon by fishing vessels from several countries. Multinational efforts to ban fishing long enough for the seeding stock to recover and then be carefully controlled have not been successful. Some countries where fishing is a minor source of income can even subsidize fleets to catch them. In Iceland, herring catches have been vital to the nation's economy and instead of subsidizing fishing efforts, the profits from fishing might well be used to subsidize other needed industries.

A number of Icelandic scientists are applying operations-research techniques to problems related to the fisheries industry (*ESN* 34-10:486 [1980]). Enigmatically most of these efforts are aimed at increasing the efficiency of the fishing fleet which already is so efficient that it must be held in check to prevent overkills.

Jacobsson finished our discussion with a smile. He said that one has to have a sense of humor to work at one's job. (Wayne V. Burt)

THE ICELANDIC HYDROGRAPHIC OFFICE

The chief of Iceland's hydrographic office is Gunnar Bergsteinson, a graduate of the Norwegian Naval Academy who served for a short time in the Norwegian Navy before returning to his native Iceland. The Hydrographic Office is principally concerned with the hydrography of harbors and approaches to Icelandic harbors. It also carries out hydrographic surveys in harbors and in shallow near-shore coastal waters. Depth determinations are made from a small 17-m wooden survey launch that has been on loan from the US Navy since 1956.

In the past, offshore depth surveys around Iceland have been made principally by Denmark, but also by Germany, Great Britain, and the US. Historically, Iceland became a sovereign state under Denmark in 1918 but only achieved complete independence in 1944. Denmark made its last major survey of Icelandic waters in 1930. The first charts issued by the Icelandic Hydrographic Office and based on the data of that office came out in 1960. The office began printing its own charts using a local printing establishment in 1965. The hydrographer pointed out to me that being small has its drawbacks. The minimum lot of chart paper that can be purchased, some 5 tons, lasts about 5 years. Charts are issued for both inland and offshore waters. These charts are now printed in English so that Icelandic fishermen will become familiar with the terms used and foreigners can also use the charts.

New offshore charts are issued from time to time. These are based on older charts and surveys from the countries mentioned in the previous paragraph plus any additional data that becomes available. They are beautifully done, and the reproduction matches any standards for charts that I have seen.

The mid-Atlantic ridge begins to surface near the southwest tip of Iceland with some peaks piercing the water surface. There are also a number of underwater pinnacles along the top of the ridge. Some of the latter were missed by the Danish surveys, because the survey lines tended to fan out from the shore like spokes on a wheel. One such undiscovered pinnacle came within 3 m of the surface until after WWII, when it pierced the bottom of a British trawler and sank it. It was so sharp that the trawler knocked the top off and lowered it to 8 m below the surface.

There has been a master station tide gauge in operation in Reykjavik for the past 26 years and one year's data on tides have been obtained by harbor

administrations at a number of other locations around the coast of Iceland. The Bidston branch of the UK Institute of Oceanographic Sciences (*ESN* 33-10:423 [1979]) reduces these data and predicts future tides under contract to the Icelandic Hydrographic Office. The tides are quite regular and there is little difference in the high waters on any given day. The highest tides occur in Reykjavik Harbor in the spring with maximum changes in elevation of over 4 m.

The predicted tides for Reykjavik Harbor are published on a calendar along with the phases of the moon. At the bottom of each monthly sheet are drawings showing the phase lag of tides around Iceland relative to the phase in Reykjavik Harbor and isolines of the ratio of the range of tides in various locations to the range in Reykjavik Harbor. Equal phase lag lines radiate out from land nearly like spokes on a wheel. The range of tides on the east coast drops to 0.3 of the range on the west coast.

Accurate tide tables are economically important in Iceland for two reasons. The first is that commercial fishermen operating in local waters have found that the catch is better at certain stages of the tide and therefore use the tide calendar to time their fishing efforts. The second reason why accurate tide tables are important is that good catches of salmon are usually made in tidal portions of Icelandic rivers only during certain stages of the tide. The best times to fish are determined from the tide tables. Salmon returning up Icelandic rivers belong to the "farmers" owning the river banks. Their control and management lie in the Ministry of Agriculture rather than the Ministry of Fisheries and the salmon are treated as a "crop". It is an extremely lucrative crop for the farmer. Foreign sports fishermen fly in to fish for salmon and pay up to $300 a day for the privilege.

The tiny hydrographic office is neat and tidy and has a businesslike air. In accordance with Iceland's policy of reverse zoning (see following article on this page) it is located near the ocean in a nice residential area.
(Wayne V. Burt)

SOME MARINE RESEARCH IN ICELAND

Iceland is a large volcanic island in the Atlantic Ocean, just about 700 miles west of Norway, which settled it in the 9th century, and approximately the same distance from Denmark, which controlled it from the 13th to the 20th centuries. In many respects, however, the island nation seems a world apart from those two Scandinavian countries. In Iceland, contrasts and anomalies abound. For example, the Encyclopedia Britannica lists leprosy as primarily a disease of tropical countries. It was a widespread, and very serious, endemic disease in Iceland, however, from about 1700 until the late 19th century.

There are other striking examples of departure from the usual pattern in Iceland. The wide, fertile valley to the east of Reykjavik has been the center of agriculture in the country for a millennium, and yet no relics of the past are evident. From all appearances, the valley might have received its first settlers in the present century. In a 9-hour drive through the valley I saw just one graveyard, and that had only half a dozen headstones. Eleven successive churches have been built at Skalholt, the site in the center of the valley where the graveyard is located.

There are no remains of ancient stone edifices in Iceland such as those that abound almost everywhere else in Europe. For centuries, houses were built of sod or driftwood, and they either burned down or washed away with the passage of time. Today, most houses are being built of reinforced cast concrete, and evidence of these should last for many centuries. I was told that it would take a large portion of a working couple's combined salary for several decades to pay for a house, and thus a large proportion of the new houses under construction were being built over an extended period of time by the couples owning them.

By law there is no unemployment. Beer is not sold. The capitol, Reyjkavik, practices reverse zoning. One can walk through a fine, new residential area and find scattered through it isolated factories, furniture stores, distributorships, and government buildings. There are no armed forces. Although Iceland touches the Arctic Circle and its southern tip is at about the same latitude as Nome and Fairbanks, Alaska, it grows a surplus of meat and dairy products and further development of agriculture is discouraged. Bananas are grown commercially in geothermally-heated greenhouses. Tomatoes are flown south to Europe in winter.

The largest research institute in Iceland is the Marine Research Institute of the Ministry of Fisheries. The institute has grown 15% since the last report that was written on it (ONRL Report 38-63); it now has a

total of about 60 employees plus crews for 4 research vessels. The institute occupies parts of 3 floors in a bright, modern building near the water's edge only a few blocks from the center of Reyjkavik. From its windows there is a fantastic view across the deep blue water to the bare high mountains on the far side of the bay.

The institute consists of the following departments: (1) Oceanography, (2) Phyloplankton, (3) Invertebrate zooplankton and benthos, (4) Pelagic fishes, (5) Mobile demersal fishes (such as cod), (6) Flat fishes, (7) Fishing gear technology, and (8) Instruments (including electronics and acoustics).

The institute's 4 vessels are stern trawler research/exploratory fishing vessels: the 60.4-m-long *HAFTOR*; the 55.9-m-long *BJARNI SAEMUNDSSON*; the 40.4-m-long *ARNI FREDRIKSSON*; and the 26.2-m-long *DROFN*. Space is occasionally available aboard ships for foreign investigators.

This article is primarily concerned with the oceanography department. It also contains a brief review of some research taking place in the Icelandic Meteorological Office.

Dr. Sven-Aage Malmberg, head of the Department of Oceanography, received his PhD under Prof. Gunter Deitricht at the Institut für Meereskunde at the University of Kiel in 1962. He emphasized the fact that the purpose of his department's research was specifically to help in fisheries research by keeping track of environmental factors that influence fisheries. These include water temperature, salinity, primary productivity, currents, oxygen, and nutrients. He said that his group's relationships with fisheries were similar to the relationship between a meteorological office and agriculture.

Malmberg is a physical oceanographer. He employs a lot of XBTs (expendable devices for rapidly determining the distribution of water temperature and salinity with depth) not only on oceanographic cruises but also on exploratory fishing cruises. The resulting data are sent by radio in real time to the UK Meteorological Office at Bracknell, near London, and to the US Navy Fleet Numerical Oceanographic Center in Monterey, California. Malmberg's group tries to make oceanographic observations in all seasons and to work as much like meteorologists as possible. His network of stations consists of lines radiating out from the coast of Iceland like spokes in a wheel. The network is inside the 200-mile economic limit. There are about 100 stations on 15 lines where observations are made at least 4 times a year.

Iceland is normally south of the oceanographic polar front separating mixtures of warm waters originating in the Gulf Stream from colder waters from the north. Some major variations in water masses around Iceland have been noted historically (for example, during the Little Ice Age winter of 1695, Iceland was almost completely icebound all around its coastline so that ships could not put to sea for a short time). It has been colder than normal during the past 2 decades. The mean water temperature around Iceland from 1924 to 1960 was 5°C, with small year-to-year variations. During the decade from 1960 to 1970 the mean water temperature dropped to 2.8°C and there were large variations from year to year. In June 1968 the temperature dropped to 0°C along the northeast coast, but by June 1971 the 0° weather isotherm had receded more than 300 miles to the north of Iceland. The same type of changes occurred in the salinity which registered a mean of 35 o/oo, and showed little variation from 1924 to 1960. In the decade 1960 to 1970, however, the mean salinity dropped to 34.6 o/oo with large variations. These variations had widespread effects on fisheries, such as a drop in local herring (*ESN* 35-3:118 [1981]); they also affected salmon catches as far away as Scotland (*ESN* 34-6:293 [1980]).

Malmberg's main interest is in the relationships between climate, the distribution of sea ice, and variations in water masses around Iceland. There is a widespread belief even in Iceland that current and oceanographic conditions are reasonably stable around Iceland. The equable warm climate is attributed to the fact that roughly the southern two thirds of Iceland is bathed in the warm waters of the Irminger Current flowing northwestward south of Iceland. Malmberg showed me one chart for an extremely warm period for all of Iceland. The warm waters of the Irminger Current flowed completely around Iceland in a massive clockwise eddy. Then he showed me a chart for a very cold period when cold water originating to the north bathed just over half of the coastline from the northwest clockwise to the southeast. In extreme years, like 1695, a cold clockwise eddy would have circled the island. The year-to-year variations are very important to the spawning of cod and other benthic (bottom) fishes.

Malmberg's aim is to focus on changes in water masses, locations of fronts, and current patterns from year to year and their effects on

fish migration and spawning. A number of researchers with whom I have spoken in Europe are studying the same variations as Malmberg from the standpoint of their effects on weather and climate in Europe. The location of the edge of the arctic sea ice pack seems to be most intriguing. In historic times it has varied considerably. From 1920 until 1965, sea ice did not touch northern Iceland. It reached the island's northern coast in 1965, 1967, 1968, 1969, and 1970, and then disappeared only to return again in 1975 and 1979.

Malmberg said that the unexpected arrival of sea ice after the long hiatus was a great shock to the people of Iceland who knew from history the adverse effects little ice ages can have on their already climatically marginal agriculture and on fisheries. During the recent cold years the cold weather has had a worse effect on agriculture than on fisheries. During 1979 farmers had to slaughter much of their livestock for lack of adequate fodder to feed the animals.

Because of their country's small size and large-scale dependence on the sea, many Icelanders are interested in oceanography. For this reason Malmberg teaches descriptive oceanography at the Teachers' University in Reykjavik so that the teachers can in turn teach it to their students.

Malmberg ended my interview with him by stating that "Climate is Iceland's worst pollutant."

Dr. Unnstein Stefánsson is Iceland's senior oceanographer. He is primarily a chemical oceanographer but has also worked in other branches of oceanography. His time was fully occupied at the institute until he became the first professor of oceanography at the University of Iceland in 1975. He still has strong ties with and maintains an office and laboratory at the institute.

Although Stefánsson is a chemist by training (he received his PhD in chemical oceanography at the Univ. of Washington in 1973 under Prof. Francis Richards), he spent most of his time until the last decade in a study of the water masses and currents around Iceland. In 1962 he published a monumental, 269-page tome on the above subject (*North Icelandic Waters, Rit Fiskideilder* Vol. III 1962, Reyjkavik). He did much the same sort of research as Malmberg. One of his most recent papers was on the subject of hydrographic conditions off northeast Iceland as they relate to meteorological factors. When Malmberg took the primary lead in hydrographic studies, Stefánsson was finally able to devote more time to various chemical oceanographic projects.

In many areas of the world a plot of water temperature against salinity will result in a curve that is characteristic of the water mass involved. The plot is a signature of the water mass. This method of characterization is more difficult in areas such as those around Iceland where water masses are actively mixing. Stefánsson believes that a better characterization of water masses near Iceland may come from a plot of water temperature versus some single chemical constituent in the water. He has tried a number of chemicals and has found dissolved silica the most rewarding. Stefánsson has done primary productivity studies in biologically rich areas on the shelf; he has studied the nitrate-phosphate relationships in the Irminger Sea; and while at the University of Washington he studied the distribution of oxygen density and nutrients off Oregon and Washington.

His present research is largely concerned with the distribution of particulate matter in Icelandic coastal waters. He is studying the particulate aluminum and iron as a function of freshwater admixtures due to runoff from glacial rivers. He is also studying areas away from coastal influences to determine the amount of particulate organic carbon in relation to primary production and chlorophyl a.

In his spare time and during his vacations, Stefánsson camps out with his family and studies the peculiar characteristics of Icelandic lakes; he has published a number of papers on this subject.

Stefánsson teaches oceanography at the University of Iceland. Two courses in physical and chemical oceanography are taught as electives to second and third year students or to students who have completed their BSc degrees. He also teaches a course in economic oceanography and one in marine pollution. Occasionally he teaches special courses in chemical oceanography.

The University of Iceland offers few advanced degrees. Students with degrees in chemistry can take one more year in chemical oceanography and do a "project" to receive a diploma in chemical oceanography.

Dr. Kjartan Thors is a marine geologist who was born in the United States of Icelandic parents. His team consists of several hired students who are doing diploma research on specific projects, and 1 technician. The main project he hopes to complete is a survey of the geology and geophysics of the continental shelf surrounding Iceland. This geographic area is of primary importance

to the Icelandic fishing industry and is the source area for raw materials for the building trades.

Thors stated that a large part of his time and effort during the 6 years he has spent at the institute (since completing his PhD degree in geology at the University of Manchester, England) have been spent in getting together a fairly complete suite of geological and marine geophysical instruments. In addition to bottom grab samplers and Kullenberg corers, he has a sidescan sonar and an EG&G 10 kj sparker for seismic survey work.

Much of Thors' work consists of cooperative studies with biologists at the institute. He has determined the characteristics of the bottom in regions where local stocks of herring and capelin spawn. At the present time he is writing up the results of the capelin spawning grounds survey.

The most readily evident substance in Iceland is bare rock. Much of the construction of roads and concrete buildings in the country is done in the southwestern part of the country in and near Reykjavik. There are no suitable and large deposits of sand or gravel in or near this area on land. Transportation costs are excessive, and as a result, large amounts of sand and gravel are mined from glacial deposits on the continental shelf. Thors is prospecting on the sea bed for more suitable, easily-recoverable deposits. A 100-km-long, 20 to 30-m-high ridge of probable morainic origin extends westward in the Icelandic shelf. Grab samples of sediments on that ridge appear to be of glacial origin.

There is no limestone on land in Iceland for use as raw material for making cement. However, there are deposits of calcium carbonate of marine origin on the continental shelf. These deposits are very rich and are unusual for the high latitude of Iceland. There also is a bay west of Reykjavik that is very rich biologically and which is a source of carbonate used in making cement and fertilizers. Thors has surveyed the area with sidescan sonar and seismic profiling. He plans to do some bottom coring to help interpret the results of his geophysical surveys. His goal is to accurately estimate the extent of the carbonate resources. He has also surveyed some carbonate deposits on the southern shelf of Iceland.

Iceland is very fortunate in that the sediments on the shelves result either from glacial action in the past or are of marine origin and are not mixed with much sediment from land except near the mouths of large rivers.

As part of his general survey of the shelves Thors has taken some grab samples and bottom cores. He has completed geophysical surveys of some major fjords and is now working out their stratigraphy and geologic history. His next large field project will be a seismic profiling study of the southeast and northeast shelves of Iceland.

Thors also does geophysical and geological studies for construction projects such as bridge foundations and the improvement of harbor protection projects.

Dr. Jon Olafsson is the only chemical oceanographer at the institute and as such he is responsible for all routine chemical analyses for salinity, oxygen, nutrients, trace metals, as well as any other analyses needed by the biologists and physical oceanographers. He started a research program on mercury in sea water on returning to the institute after completing his PhD requirements under Dr. J.P. Riley in Liverpool. His reason for choosing mercury as the first trace metal to be studied stemmed from recent publications that reported quite high levels of mercury in the sea water around Iceland and in the arctic waters north of Iceland. He devised a new method that was more sensitive than other methods previously used for sea water and less sensitive to interferences from other metals. He actually found much lower concentrations of mercury in local waters than had been reported (less than 5 ng/liter).

At the May 1978 ICES (Intergovernmental Council for the Exploration of the Seas) subgroup meeting on contaminant levels in sea water, Olafsson was asked to coordinate an intercalibration study of the determination of mercury in sea water. Duplicate sea water samples with known concentrations of mercury were sent out to various laboratories. Thirty-two laboratories from 17 countries returned their measurements of the concentration of mercury to Olafsson. The results, which will be published soon, were very favorable and showed high levels of performance.

Olafsson has also studied other trace metals in marine habitats. He found lead, probably from automobile exhausts, being concentrated in mussels (*mytilus edulis*) in Reykjavik Harbor. He has also recently completed work on 90 samples of mussels from southwest Iceland to determine the trace metals in them. He has done some research on the geochemistry of rhenium in sea water. He believes that much of the behavior of trace metals in sea water is not well understood largely because analytical

techniques now available are not sensitive or accurate enough to detect the small differences in concentrations of trace metals in different samples of sea water.

Olafsson has studied the contributions of trace metals and other chemicals that come from the process of leaching from fresh lava that has flowed into the ocean. He has also studied the contributions of hydrothermal sources on the sea floor in depths from 9 m to 200 m and in lakes. Some Icelandic lakes have interesting physical characteristics like those of a pot of water on a stove. They are heated from below, and this causes overturning.

Olafsson believes that trace metals may help in tracing water masses. On a single cruise around Iceland he can sample water originating in the Gulf Stream, water from arctic and polar regions, and all sorts of mixtures of their water masses, using trace metal concentrations in an endeavor to tell possible differences between water masses. He was at sea working on this subject for 11 weeks in the summer of 1980.

Olafsson is about halfway through a projected 4-year study, in collaboration with Stefánsson, of the effects of large glacial rivers on the chemistry of Icelandic coastal waters.

The Icelandic Meteorological Office has recently begun a program to study the location of the southern boundary of sea ice and its relationship to weather and effects on shipping under the direction of of Dr. H. Jacobsson, who has recently returned to his native Iceland from 2 years service with the Meteorological Service of Ontario, Canada. This leads to a study of variations in the East Greenland Current that transports the ice to the south.

Traditionally since the early 1900s, the service has operated a large network of seismological stations. Last year it began a cooperative program with the US Carnegie Institute to operate eight strain gauges that are placed around the most recent active volcano, Hecla, in southwest Iceland, close to Reykjavik and hence of great interest. (Wayne V. Burt)

OPERATIONS RESEARCH

FUZZY SETS

As everyone who went through elementary school in the last 25 years (or had a child in elementary school during the same period) knows, most of mathematics is based on the theory of sets. A set is any collection of elements having in common certain properties. Mathematical sets, of course, are characterized by very well defined properties. There is no difficulty understanding exactly what is meant by "the set of whole numbers greater than 3 and less than 13" or "the set of all isosceles right triangles." The problem comes when we attempt to apply set theory to situations in the real world where sets are not well defined. Exactly which elements are included in the sets of "bright children" or "acceptable tax levels" or "well-designed automobiles" and which are excluded?

As Bertrand Russell observed in 1923, "traditional logic assumes that precise symbols are being employed, and is therefore not suited to terrestrial applications." In 1965 Lotfi Zadeh (Univ. of Calif., Berkeley) started developing a formal mathematical theory applicable to such ill defined sets, which he called "fuzzy sets." Zadeh was already a well known scholar and his theory immediately drew widespread attention; however, the consensus seemed to be that it was elegant, but not applicable. In the intervening 15 years most people have changed their minds on this. The theory has been greatly expanded and innumerable applications have been found. Zadeh is still the guru of the field; the unquestioned leader in Europe is Prof. Dr. Hans-Jürgen Zimmermann, who has been described in *ESN* 33-11:472 (1979).

Zimmermann was the featured speaker at a 1-day meeting on Fuzzy Sets held on 12 December 1980 at the Europa Lodge Hotel in Darlington, Durham, in the northeast corner of England; the meeting was a national event of the Operational Research Society of the UK. It was Zimmermann who pointed out at this meeting, as an example of the growth of fuzzy-set activity, that there are 8,000 workers in this field in the People's Republic of China and that they have been submitting many articles each month for publication in *Fuzzy Sets and Systems*, an international journal now in its fourth volume, of which Zimmermann is the editor. Other speakers at the meeting were Philip Boxer (London Graduate Business School) and N. Mandić (Elec. Engineering Dept., Queen Mary College, London Univ.) who was standing in for his colleague, E.H. Mandani, who was unable to be present. The meeting was chaired by John Hawgood (Durham Univ.) and organized locally by David Livingston who works for Vickers Ltd. in Newcastle-upon-Tyne. (Newcastle and Durham are both a little bit north of Darlington; one cannot get very far

north of Darlington without being in Scotland.) In addition there were 36 delegates each of whom paid £35 ($84.00) to attend the meeting.

Zimmermann started by giving the above quotation from Russell and one from Zadeh's 1965 classical paper in which he proposed the name fuzzy sets and asserted that "precision and significance (or relevance) become almost mutually exclusive" in complex systems. Zimmermann mentioned another intellectual antecedent of fuzzy-set theory: the theory of multivalued logic developed by Tarski and others half a century ago. There does not exist a unique multivalued logic; neither does there exist a unique fuzzy-set theory. If multivalued logic is extended to the continuum, it is indeed very close to fuzzy-set theory.

Zimmerman pointed out that there is nothing fuzzy about the theory of fuzzy sets. It is a formal theory in mathematics, being the link between the models, on the one hand, which are precise, and the world of real phenomena, on the other hand, which are fuzzy. In mathematical terminology, given X = (x), a fuzzy set A in X is defined as a set of ordered pairs

$$A = [x, \mu_A(x) \mid x \varepsilon X] \qquad (1)$$

In other words, for each element x in the universe X which is included in the fuzzy set A, there is also assigned a membership function $\mu A(x)$ which is a number between 0 and 1 which expresses the degree to which x is in A. Crisp sets, the name now given to classical or nonfuzzy sets, can be considered fuzzy sets in which $\mu_A(x) = 1$.

For example, consider the crisp set which is speed to the nearest ten mph, namely 10 miles per hour, 20 mph,.... Then the fuzzy set consisting of "comfortable speeds for a long trip" might be (10,0), (20,0), (30,0.7), (40,0.75), (50,0.85), (60,1.0), (70,1.0), (80,0.6), (90,0.3), (100,0)... There were also some postulates and definitions; for example, two fuzzy sets A and B are equal if and only if

$$\mu_A(x) = \mu_B(x) \qquad (2)$$

for all x in X. Furthermore,

$$\mu_{A \cap B}(x) = \text{Min}\,[\mu_A(x), \mu_B(x)] \qquad (3)$$

$$\mu_{A \cup B}(x) = \text{Max}\,[\mu_A(x), \mu_B(x)] \qquad (4)$$

Equation (2) says that 2 fuzzy sets are equal if and only if the membership function is identical for every element. (3) says that if we look at the set consisting of elements belonging to both of the fuzzy sets A and B, then the membership function of any particular element in that set is the smaller of its membership functions in the other two sets. (4) says that if we look at the set consisting of elements which are in either set A or set B or both, the membership function of any particular element in that set is the larger of its membership functions in the other two sets.

Zimmermann's principal subject was the application of fuzzy-set theory to decisionmaking and decision analysis, and he particularly applied this to the classical theory of linear programming, which is among the simplest well-defined classical techniques of quantitative decision analysis, and to the theory of multicriteria decisions, which is one of the most difficult areas and one which is very active in modern decision-theoretic research. Quantitative decision theory is normally associated with maximizing or minimizing some so-called objective function (or criterion function) subject to stated constraints. Here we are assuming that the objective functions and the constraints are all fuzzy sets, and Zimmermann asserted that one should examine the intersection of all of these sets which, in accordance with (3), has the minimum of the membership functions of all of the fuzzy sets representing objectives and constraints. Thus fuzzy-set theory is quite symmetrical in constraints and objectives, which is *not* true of classical decision theory.

As an example, he considered the board of directors of a corporation, trying to determine the size of the dividend they should declare, subject to two constraints: first, that the dividend should be large enough to be "attractive" to stockholders; and second, that the dividend should be small enough that it should be considered "modest" in connection with the forthcoming negotiation with the labor union. The fuzzy set of "attractive dividend" could for instance be defined by:

$$\mu_A(x) = \begin{cases} 1 & \text{for } x \geq 5.8 \\ (1/100000)\,[-464x^3+7961x^2-14530x+7033] & \text{for } 1 \leq x \leq 5.8 \\ 0 & \text{for } x \leq 1 \end{cases}$$

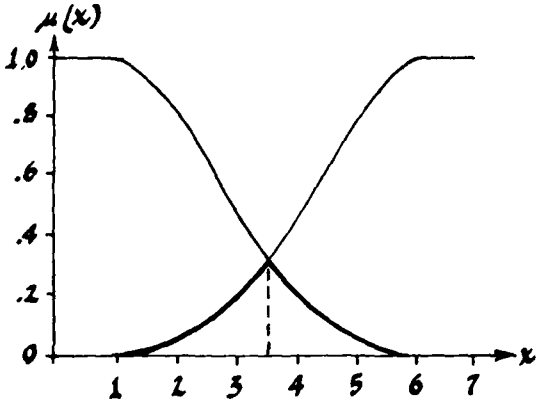
The fuzzy set (constraint) "modest dividend" could be represented by:

$$\mu_m(x) = \begin{cases} 1 & \text{for } x \leq 1.2 \\ (1/100000)\,[3270x^3-31805x^2+62206x+65501] & \text{for } 1.2 \leq x \leq 6 \\ 0 & \text{for } x \geq 6 \end{cases}$$

The fuzzy set decision is then:

$$\mu_D = \text{Min}[\mu_A(x), \mu_m(x)]$$

The situation is shown in the figure, where the light curves represent the constraints and the dark curves represent the decision. There is then some justification for considering that dividend with the highest degree of membership in the fuzzy set "decision" as the "most desirable" (in classical decision theory this is called the maximin) which would lead to a dividend of 3.5%, as indicated by the dotted line on the figure.



On the other hand there are some situations in which this minimum is clearly inappropriate. For example, a professor has given an examination question in which there are two possible ways of answering. A particular student has answered both ways; in the first way his answer would have been worth 70%, and in the second it would have been worth 90%. In fuzzy-decision-theoretic terms, his membership function for the set "good responses to the first question" is 0.7, and his membership function for the set "good responses to the second question" is 0.9. It is clearly appropriate here that the degree of membership in the set "good solutions to the question" should be the larger of these two; that is, that the professor should use the maximum formula (4) and award the student 90%.

This led to Zimmermann's discussion of some of the forefronts of fuzzy-set theory, and his own research. Specifically, humans use nonverbal connectors in reasoning; when talking they use the nearest verbal connector. But neither (3) nor (4), nor any of several other formulas which Zimmermann discussed, adequately predict human decisions. He is therefore seeking a "merging connective" such as a "compensatory *and*" where *and* is used in its technical sense in formal logic; that is, something between the classical *and* which leads to (3) and which provides no compensation on the one hand, and the classical *or* which leads to (4) and provides the maximum amount of compensation on the other hand. He discussed the attempts to find an appropriate formula for a degree of compensation.

Along the way he discussed fuzzy linear programming and gave some fascinating examples from his consulting experience. One of these concerned the attempt to optimize the loading of containers onto a ship. One of the constraints was the total number of containers which could be loaded, and it turned out that the actual solution had more containers than were theoretically possible. Apparently, containers were being piled on top of each other in some cases in ways which had not been considered theoretically possible. Thus the constraint concerning the total number of containers which could be loaded onto a given floor space was a fuzzy constraint which could be more or less exceeded by such piling. Similarly, the objective function itself is often fuzzy. One classically states the objective function as minimizing cost, but this may not be the real objective. The absolute minimum cost might be $9,342.67, while any cost up to $9,500 might in fact be acceptable. In this case we have a set of acceptable costs with membership functions such that anything above $9,500 has membership function 0, $9,342.67 has membership function 1, and costs which are in between have membership functions which are in between. Formulating problems in this way leads to quite straightforward solution by the classical techniques of linear programming, but frequently yields quite different answers, and answers which are much more realistic. Still a further example concerned assigning spaces on a factory floor to various functions. It turned out that the stated constraints on spaces were the absolute minimum that were acceptable, and in each case from 5-10% more space was desirable. Thus if the classical statement was 50 sq ft, the fuzzy set showed a membership function of 0 for less than 50 sq ft, 1 for more than 55 sq ft, and some appropriate fraction in between.

Boxer, who is a psychologist, talked about a problem space defined relative to the needs of a decision-maker, and various methods of "construing" decisions, including "propositional constructs," "pre-emptive constructs," and "constellatory constructs." He described a computer program he had written, called Nipper, which was designed for formalizing membership

functions in fuzzy sets. He talked specifically of the problem of choosing one of five makes of automobile, each of which was rated according to 13 criteria such as roominess, cost, power, etc. The ratings might be strictly ordinal (car A is preferred to car B according to this criterion) or there might be some aspects of cardinality (car A is much preferred to car B according to this criterion). He stressed that he used all this as a consultant to help decisionmakers clarify their objectives.

Mandić also had a computer program written to perform a similar function. He would state the criteria, state the alternatives, including a "goal alternative" which was sort of the optimum which might be expected, and then on a high-low scale "linguistically relate" all alternatives with respect to all criteria. For each alternative he would compute the average "linguistic distance" from the goal and then select that alternative least dissimilar to the goal. By "linguistic" he meant such descriptions as high, not very low, above average, and not below average (note that no two of the above four are identical).

Zimmermann asked each of the last two speakers whether his procedures were descriptive or normative. Boxer stated that his was strictly descriptive, a way of getting the manager to explain how he sees things relating. Mandić said that his scheme had both descriptive and normative aspects.

In the final session, Zimmermann discussed again what he considered to be the two key problems in the application of fuzzy-set theory to decision analysis: first, determining the membership functions; and second, determining the combinatorial rules (such as the degree of compensation which he had discussed earlier). He also mentioned a number of additional applications, and reported that a company in Denmark had begun producing commercially a cement-kiln controller which uses fuzzy logic. Classical controllers sometimes overact, and in this respect are not as good as people; fuzzy logic is a method of avoiding such overaction. He also described an application of fuzzy-set theory to the solution of assignment problems (how to assign a set of men optimally to a set of jobs) in the German military. Fuzziness here concerned the degree to which a particular man is qualified to do a particular job. A remarkable discovery had been that the shapes of membership functions were frequently the same over a wide variety of sets—for example, the shape of the membership function for shooting ability seemed to be the same for shooting rifles and for shooting artillery. Storing the shapes of these functions in a computer permitted the computer to work out an optimal assignment. Finally, Zimmermann mentioned that at the joint meeting of The Institute of Management Sciences and the Operations Research Society of America in Washington, DC, in May 1980, a fuzzy decision algorithm had been demonstrated on a minicomputer. He felt that there was danger in this. The algorithm was based on a normative minimax criterion and people therefore might make decisions on a minimax basis without recognizing that they were doing so. However he was very enthusiastic about the possibilities for interactive computers, where the operator could, for example, modify the degree of compensation.

Zimmermann gave a number of references, mostly from the journal *Fuzzy Sets and Systems*, which is published by North-Holland.

By the end of the meeting, all of the participants were pretty well convinced that fuzzy-set theory had come of age and that it would be used more and more both in decisionmaking and in control operations. (Robert E. Machol)

OPERATIONS RESEARCH AT CIBA-GEIGY

Ciba-Geigy (C-G) is a large company by any standards. Their sales last year were some 12 billion Swiss francs (SF), worth at that time some $8 billion, almost all in pharmaceuticals, dyestuffs, agrochemicals, and plastics. C-G was formed just over 10 years ago by the merger of the Ciba company and the Geigy company, two Swiss manufacturers, both devoted, for the most part, to the businesses listed above. Both have long and distinguished histories, and their laboratories have produced at least one Nobel prize (P. Müller, 1948). The company now employs about 20,000 people in Switzerland and another 60,000 people around the world, through 60-odd subsidiary companies. These companies are highly autonomous; in particular, they do most of their own data processing, operations research (OR), and the like. The company's headquarters is at Basel, a German-speaking Swiss city which borders on both France (which calls it Bâle or Basle) and Germany. In Basel are the headquarters groups for each of the four divisions manufacturing the four types of products mentioned above. These divisions also are rather autonomous and responsible for their own marketing, production, and research. Also at the headquarters are "functional groups" involving such things as personnel and

finance. One of these functional groups, called "management services" and employing nearly 300 people, has the corporate computing and information systems and also an OR group. The OR group has been for many years budgeted for 10 people, but has actually always had 12 to 14, which says something about the success of the group and its good relations with the head of management services.

The OR group is headed by David Hare, an Englishman who came to Switzerland 12 years ago. He had taken a PhD in mathematics at Liverpool University, doing a thesis on the ecology of Lake Windermere, which must have been one of the first OR-related doctoral theses in the United Kingdom. He came to Basel for a short stay and now appears to have become a permanent resident. The remainder of his group are about half Swiss, with a smattering of English, French, Norwegians, Americans, and Germans. About half have the doctorate and all have at least a Bachelor's degree. About 3/4 were trained in mathematics, physics, or engineering (I was surprised to discover that there were no chemists, considering the nature of C-G's business); the remaining 1/4 were trained in business administration or economics. The large number of foreigners is doubtless due to the lack, until recently, of Swiss trained OR people.

As noted above, some of the subsidiary companies, notably those in the US and UK, have their own OR groups, and there is also a "research group" at headquarters which includes a large number of people who do statistics, quality control, and certain kinds of simulations such as those involving chemical reactions. However the OR group at Basel has wide ranging responsibilities and is free to do almost any kind of study, provided it can get a sponsor. Eighty percent of its budget is underwritten by its customers, generally the divisions or specific groups within the divisions. Each such underwriting is based on a "project proposal," a document of 3 to 6 pages which includes the expected costs and the expected benefits of the project. After the customer has signed this proposal, appropriate costs of the OR department, plus computing and other service costs, are charged to the customer's budget. Hare can do whatever he likes with the remaining 20% of the budget, which gives him the opportunity to do preliminary work on projects which are later underwritten. The fact that most of the projects are paid for by users obviously reduces the flexibility of the group. There are frustrating occasions when there are projects that they feel ought to be done but no one wants to pay for; but on the whole Hare feels that this system is highly advantageous because it ensures user interest and greatly increases the probability that the results of the studies will be implemented.

An unusual feature in this organization is that each year the OR group makes up a plan describing what projects it will be working on for the next 3 years. One-fourth of the available man-hours are kept free for ad hoc studies that may come up, and many of the plans for more than 1 year in advance are subsequently modified, but this is still a remarkable degree of planning for an OR group and indicates that they do indeed have a framework within which are fitted those studies to which their resources will be applied.

There is no hierarchy within the OR group, but the most senior people, Adrian Wood, Lionel Lecoq, and Lothar Seinege, are frequently made project leaders; 2 or 3 of the other members of the group may then be assigned to such a project part time or even full time. I talked at some length to Lecoq and Seinege about the projects on which they have been working.

Lecoq took a degree in aeronautical engineering in Paris in 1964 and then received a doctorate in electrical engineering from Berkeley in 1970 (his education having been interrupted for 2 years by the requirement for military service in France). He went to Geigy immediately after receiving his doctorate and has been there ever since. One project on which he has been working almost continuously concerns production planning. He worked on this full time for his first couple of years and he told me the result was basically "a flop." The model was much too ambitious and much too complex. It attempted to cover both the pharmaceutical division and the dyestuff division in a single model. It was not sufficiently modular; that is, instead of being built in parts, each of which could be tested and modified and then put together, it was an attempt at a monolithic structure. The OR people had no data-processing support and had to do their own programming, which perhaps was not first-rate; and finally the whole thing was badly affected by the necessity to modify it when the fusion of the two companies took place. Even so, this abortive effort more than paid for itself after a tentative decision had been made to build a new special-purpose plant capable of manufacturing only a single type of pharmaceutical product. Lecoq's production planning model indicated, first, that special-purpose plants were undesirable; but more specifically, it demonstrated

conclusively that sufficient capacity existed so that the new plant was unnecessary. It was therefore decided not to build this plant. When the market for that particular type of product subsequently collapsed, the OR workers who had prevented the plant from being built became heroes in the eyes of the corporate headquarters.

Subsequently the model was modified to eliminate most of the above difficulties. The dyestuffs were dropped; the model only described the pharmaceutical production, and even there it was limited to a small area. All the programs were rewritten by professionals. The thing was done in modular fashion, and it was specifically directed to middle-range (as distinguished from long-range) planning. It is now used extensively not only in Switzerland, but also in the plants of many of the subsidiary companies such as those in England and the United States.

Lecoq showed me some typical computer output from this model, and it is quite impressive. The model plans for 65 weeks into the future, week by week. It starts with a "budget" of what quantity is needed of each product in each week and then schedules the manufacture of each product through its many stages and many machines. The network diagram for the manufacture of some of these pharmaceuticals is extremely complex, raw materials being used to make certain products which then become raw materials for the manufacture of other products, and so on through as many as a dozen stages, with any one of the stages using as many as a dozen different intermediate products. There are some 2,000 intermediate products and a wide variety of machines, some of which can be used to make many different products. And there are precedence relationships for a particular product on a set of machines (e.g., it must go through machine A before machine B). The optimal solution to such a complex scheduling problem cannot be found, but some highly sophisticated heuristics are used to produce an acceptable, and near-optimal, schedule. The computer output shows which products are made in which quantities on which machines in which weeks. It also summarizes, flagging those products which have difficulties and those machines which are creating the difficulties. For example, 3,800 kg of a certain product might be required by the 17th week; the machine might print out that only 2,100 kg would be available at that time and the remainder would be available 5 weeks later. For a bottleneck machine the computer indicates the amounts of particular products that would be required from other sources in order to free that machine for the necessary amount of time. These and other difficulties may then be resolved in a wide variety of ways. For example, one may go back to the customer who has originated the demand for the product (frequently that customer is another part of C-G) to see whether indeed the requirement can be relaxed either in time or in quantity; or it may be that a particular machine that has idle time can manufacture a product for which it would not normally be used. The computer printout also includes for each machine its entire schedule: for production, for cleaning, for "blocked time" (for example, its use in pilot production runs), and its free time. It also includes all manpower requirements. These may have been put in as part of the constraints of the problem (for example, 40 men available, except during July and August when, because of vacations, only 36 men will be available); if no manpower constraints have been given as inputs, the computer shows what manpower is required to fulfill the schedule. The computer also prints out any necessary use of overtime, of multiple shifts, and of weekends. Although this model is currently being heavily used, especially by the production managers who make from it their detailed production plans, it is continually being worked on and improved.

Lecoq has also been very much involved in inventory control problems. These are particularly severe at C-G. There are, as mentioned above, a large number of intermediate products, and in general each of these products is manufactured in batches (as distinguished from continuously) and indeed in large batches, inasmuch as it is highly inefficient to make small batches. There is thus an enormous amount of in-process inventory, probably in excess of 100,000,000 SF. Control of this inventory is difficult in pharmaceuticals, but even worse in dyestuffs where there does not exist an appropriate data base for the in-process inventory. The basic problem is of course the familiar one faced by most manufacturing organizations, balancing off excessive production costs for frequent small batches against excessive inventory holding costs for infrequent large batches. It is complicated here by a number of factors. The OR group has models which give upper bounds and lower bounds for the inventories of particular products, and which also give the so-called "economic order quantities" which optimize the balance between production costs and inventory costs for each of

these products. However, they have found (as many other firms have found) that the difficulties arise chiefly from the poor quality of the forecasts. Given a precise forecast of demand, one can balance off not only the economic order quantity, but also the inventory cost if too much is held in stock against the shortage cost if not enough is held in stock; but when the forecasts are very bad, one will suffer excessive shortages when the forecast is lower than the actual demand and excessive inventory holding costs when the forecasts are higher. In many cases an active pharmaceutical compound is manufactured in Switzerland and then sent to "conditioning plants" around the world where it is made up into finished products such as creams, ointments, and pills. In such cases the demand comes largely from subsidiaries, and one would think it would then be easy to get good forecasts of the demand, but often this is not so, because part of the demand may be met by production in the subsidiaries themselves or from competitors rather than from the Swiss part of C-G. In any case studies on in-process inventories continue as a main consumer of OR manpower.

A somewhat easier problem is the inventory of spare parts. There are 10,000 different items, worth at present about 26,000,000 SF, in inventory. For some of these items there is little choice: for a certain type of reaction tank there must be precisely one spare. But for things like light bulbs the analysis of reorder points (how low the inventory must get before a new order is issued) and reorder quantities must be performed. Much of this inventory is maintained in three automated warehouses. These warehouses were built without input from the OR department, but the OR people were subsequently asked to help operate them. They attempted to apply the usual algorithms found in the literature for automated warehousing and discovered that they did not work: great queues built up of material waiting to go on the conveyor belt. The problem was solved by sorting the items demanded from the warehouse by package type so that the automatic crane did not have to move back and forth so much.

Seinege took his doctorate in mathematics at the University of Zürich, worked in industry for a little more than a year and then came to C-G's scientific computing group; he transferred to the OR group in 1975. He told me about a number of OR projects which had been highly successful, many of them remarkably simple. For example, while the subsidiaries are largely autonomous, they frequently need infusions of capital for such purposes as building new plants. When such a request for capital comes in, it is necessary to answer questions about what will happen in terms of taxes, currency restrictions, various possibilities for inflation, and the like. Similarly, it frequently happens that a particular country which is undergoing inflation has price-control regulations, so that it becomes desirable to contract the company's activities by closing down plants or reducing the number of products manufactured. Again this leads to a number of options to be examined. The OR group has built a number of simple simulation models (Seinege told me that these often take only 2 or 3 man-months of work to complete) which, while they do not yield optimal solutions, do permit calculation of the probable results from certain types of alternative actions. In particular, when currency fluctuation started to become severe and the Swiss franc rocketed, these models were able to show the impact for C-G of various tactics which they might adopt, and created a good deal of good will for the OR group (Hare told me) because the models were of considerable use and nothing else was available for this purpose.

Another particularly successful set of projects have been those on planning and budgeting models (where a "plan" is for 5 years and a "budget" is for one year). Essentially these models take financial inputs from all over the world for periods of 1 or 5 years, put them into a computer, aggregate them in various ways, and allow managers to interact with the computer by asking various types of "what if" questions. Again, the most useful of these models have been those relating to various exchange rates. Some of them have been operationalized to the point where the planning departments in the divisions have utilized them without the help or even the knowledge of the OR group. This is a measure of success.

Another project which everybody assured me had been an outstanding success was the one which they called "market segmentation." A particular division has found that when it introduces a new product, it is not generally able to contact every one of its prospective customers. The problem is to determine which customers are most promising. This is done by getting a history of the reactions of each customer to each of a series of "variables," such as how this customer feels about cost, how he feels about various indirect costs involving the difficulties of using the

product, and how he feels about various aspects of the performance of the product. A large amount of such data was collected over a period of 2 years and then subjected to factor analysis, which yielded 3 to 5 significant factors. For a particular new product, each customer was graded on his reactions to these factors to determine whether or not he should be contacted as part of the campaign. This model was put into effect in one region of Holland where it did considerably better than a control group with the same product in another region of Holland. A market research company was then commissioned to study the model and found a high correlation between the predictions of the model and the actual results. The model is now being used worldwide by C-G subsidiaries.

Hare told me about several other projects. They built a number of econometric models. One used a large amount of data on the first 36 months of sales for new pharmaceutical products. Regression functions were developed for each of 11 new products, showing the dependence of sales on 4 types of marketing expenditures, namely advertising in trade journals, giving samples to physicians, sending literature to physicians through the mail, and "detailing"—sending specially trained salesmen called "detail men" to call on physicians. There were special difficulties with the data: it is all discrete, for one thing; there may be several months during which one or more of these four methods is not used; and it is difficult to determine the time lag between cause and effect. Nonetheless, 7 of the 11 regression functions were statistically significant. The principal and startling conclusion was that detailing was less effective than had been believed, and that in 5 out of the 7 significant models the return from detailing had been less than 1 SF of sales per SF of marketing expense. Because detailing has classically been a fundamental marketing method for pharmaceuticals, the marketing people have been very slow to accept this result. The OR people are hoping to try controlled experiments, but these are difficult. It would be nice to pick a set of regions at random, increasing detailing expenses in some while other types of marketing expenses were increased in others. The difficulty is that one cannot isolate the effects for a particular region, because C-G sells to wholesalers, and a wholesaler in Zürich, for example, may supply a customer in Bern. They are considering an experiment whereby a market research agency would make arrangements for a large number of physicians to allow the agency to look at all the prescriptions they write. Such a test would clearly be extremely expensive.

It is always interesting to conjecture as to what makes a particular OR group effective or efficient or successful. This one seems to have kept its customers happy and to have produced a number of highly useful models. They have made a formal attempt to evaluate each project 2 to 3 years after it has been completed and implemented, and to evaluate the payoff and compare that payoff with the cost. They have a number of highly trained mathematicians, but they seem to use comparatively little sophisticated mathematics in their approaches. They build very simple models which can be used by managers to answer "what if" types of questions. This appears more and more to be the wave of the future for operations research. (Robert E. Machol)

OPERATIONS RESEARCH IN BELGIUM—PART I, SOME UNIVERSITIES

The northern part of Belgium, called Flanders, is occupied primarily by people who speak Flemish, a language almost identical to Dutch; the southern part, called Wallonia, is occupied by Francophones or French-speaking people. French was at one time the exclusive language of instruction in the universities. Starting about 50 years ago, the Flemish majority began receiving instruction in their own language, and eventually each university in the country became exclusively French-speaking or Flemish-speaking. The most famous change in this process occurred a dozen years ago in Belgium's oldest and most prestigious university, the Catholic University of Leuven, which was in Flanders (its French name is Louvain); it split into two universities, the French-speaking part moving 20 km to the south (to get into Wallonia) where they established not only a new university but also a new city, Louvain-la-Neuve.

Furthermore, every university in Belgium is either a state university, or private; there is no distinction between the government subsidies which they receive, but the state has a good deal to say about who become professors in the former. Each private university is also either explicitly Catholic or explicitly not so. It is unusual for a graduate of a university of one language

or religion to be hired by a university of the other language or religion, and scientific intercourse between scholars at different universities tends to be largely restricted to universities of the same class. Most of the operations research (OR) people whom I met in Belgium stressed to me the isolation created by these differences, and the adverse effect which that isolation had on research.

The Belgian Operations Research Society, SOGESCI (GE for "gestion," a French word for management) was a small group a decade ago, but grew to a large society under the leadership of Jean Pierre Brans during his presidency (1972-1975) and now has some 300 members. Moreover, these members are extremely active. At the last two meetings of EURO, the Association of European Operational Research Societies within IFORS (*ESN* 33-8:337 [1979]), the Belgians have had the second largest attendance (after the host country), and at EURO IV in Cambridge in July 1980, there were actually more papers delivered by people from the small country of Belgium than by people from the large country of Germany. At meetings of the society, each speaker used to speak his own language. Scientists in Belgium can usually understand both French and Flemish, but to avoid the political problem of Flemish versus French the meetings of SOGESCI these days are generally held in English. The present president of SOGESCI is F. Broeckx, a Flemish speaker, and the president before him was C. Debruin, a French speaker; Brans, the president before that, is one of the few Belgians who cannot be classified as French-speaking or Flemish-speaking. He speaks both fluently, and holds chairs in both the Flemish and French parts of the Free University of Brussels.

Brans took his doctorate at the Free University of Brussels, in 1966, in actuarial mathematics of a highly theoretical nature, but then went into mathematical programming. For the past many years he has been concentrating on multicriterion optimization: mathematical programming and similar problems in which several different criteria are to be maximized or minimized subject to appropriate constraints. There are three basic approaches to such problems: (1) Utility theory: aggregate the criteria in some way, such as by weighting, or by melding them all into a single utility function. This was the most popular approach a long time ago, but Brans now asserts that it is the worst way. Among other reasons, such aggregation can hide insights or be very misleading. For example, the utility of one action exceeding that of another (in accordance with a particular weighting function) hides the fact that the preferred action may be inferior to the other under some of the criteria. (2) Interactive methods: discussions between the decisionmaker and the mathematician or computer. For example, two different solutions are presented to the decisionmaker, one better by one or more criteria but poorer by one or more of the others, and the decisionmaker is asked which of these two solutions he prefers. (3) Dominances: the method on which Brans and most of his team of professors, assistants, and doctoral students are working. The idea is to locate strategies or actions which dominate other strategies or actions, in the sense that they are better by at least one criterion and at least as good by all the others. The dominated strategies are eliminated, and various alternatives are then available for choosing among the remaining "admissible" or "efficient" set. Such approaches have not only been worked out in theory but also have been applied to a wide variety of realistic decision problems. For example, one of Brans' doctoral students, M. Despontin, has just completed a doctoral dissertation applying such multicriteria decision methods to econometric problems for the first time. Despontin has also just published a catalog of worldwide multicriteria decision methods.

Brans has been extraordinarily busy on both the national and international level in professional activities in operations research. As indicated, he was president of the Belgian society for three years. He was one of the founders of EURO, has been chairman of the program committee of some of its meetings, treasurer of EURO, and is now its president-elect. (He will be its fourth president. The first was Zimmermann [*ESN* 33-11:472, 1979]; the second Rapp [*ESN* 33-12:529, 1979]; and the third Tomlinson [*ESN* 34-6:307, 1980].) He has been a vice president of the International Federation of Operations Research Societies and chairman of its publication committee and is editor of the proceedings of the 9th triennial meeting of that federation to be held in Hamburg in July 1981. He was head of the department (called the Center for Statistics and Operational Research) from 1970-1973 and dean of the Faculty of Economics from 1975-1978. With such heavy administrative duties it is remarkable that he has done any research at all.

Cluster analysis is a famous statistical technique involving classifying entities into subsets (called clusters)

in such a way that similar entities are assigned to the same cluster and dissimilar entities to different clusters. This is, of course, a multicriterion decision problem, since on the one hand it is desired to make the elements from a single cluster as homogeneous as possible, and on the other hand to make the differences between different clusters as large as possible. For example, in mathematical terms, one criterion might be to minimize the maximum dissimilarity (or "distance") within any single cluster; a second criterion would be to maximize the minimum dissimilarity between elements of different clusters. Quite different classifications, or "partitions," will be performed according to the two criteria; as always with multicriteria problems, the objective is to find a "best" compromise. Leonard Kaufman, an associate professor (literally chargé de cours, or docent) with Brans, who took his PhD a few years ago under Brans and Pierre Hansen (see below), is working on multicriterion approaches to this problem. Particularly, he has been applying such methods to the study of iron meteorites. About 500 of these have been found in the world to date (most meteorites are not of the iron type); a Dane by the name of K. Esbensen has collected the data on all of them, including chemical analyses and physical properties such as conductivity and the like, and sought the collaboration of Brans' group in interpreting the data. His analyses had classified the meteorites into two groups based on their chemical composition. Kaufman and an assistant named D.L. Massart have applied more sophisticated clustering methods and discovered additional significant variables and two additional clusters. The clustering techniques have also been applied to a number of problems in analytical chemistry, and Kaufman and Massart have actually published a book entitled *Evaluation and Optimization of Laboratory Methods and Analytical Procedures*, a remarkable, special-purpose application of OR.

Another person working on cluster analysis is Pierre Hansen, who took his doctorate at the Free University of Brussels in 1974 and now holds a chair in the department of OR and computer science at the University of Lille in France and the position of research associate in the department of computer science and management at FUCAM—F for Faculty, U for University, CA for Catholic, and M for Mons, a city near the French border on the road from Brussels to Paris. Since there is only a single faculty, this is not strictly a university. Hansen has been using mathematical programming to optimize cluster analysis (it is interesting to note that Rinnooy Kan, described in Part II of this article, is using cluster analysis to optimize mathematical programming). If the objective function of a cluster analysis is made precise, mathematical programming can be used to perform the optimal partition into a stated number of clusters. This precision is obtained by defining appropriate indices for the two criteria mentioned above. Specifically, given a measure of distance between any two of the entities to be clustered, the "diameter" of a partition is the maximum distance between any pair of points in the same cluster; this diameter is to be minimized. The "split" of a partition is the minimum distance between two points in different clusters; this split is to be maximized. Hansen, working with Michel Delattre, who has recently completed a doctorate under Hansen, has developed computer algorithms for finding all efficient partitions into a given number of clusters, and then for choosing among these. With another recent doctoral student, P. Louette, Hansen has worked on cluster analyses with extraordinarily large data sets (up to 40,000 entities). This work involves essentially the streamlining of computer programs.

There are three universities or university-like organizations in Mons: FUCAM; the Ecole Polytechnique, which is also Catholic but has only a single faculty (of economics), so that it cannot be called a university; and the State University of Mons. Mons is in the French-speaking part of Belgium, and so French is the language of instruction in all three of these schools. Students in Belgium graduate from secondary school at the age of about 18. They then go to a university (or equivalent faculty) where after 2 years they receive a "candidate." Following the candidate degree, they specialize and eventually receive a "license" (pronounced leesawnse in French) which requires 2 additional years for some subjects such as mathematics, 3 additional years for others such as engineering, and 5 additional years for medicine. The Ecole Polytechnique has *only engineering students* and therefore the students require 5 years at the university before obtaining their license. There is also a small amount of graduate instruction. In particular the Department of Mathematics and Operational Techniques awards the degree of "civil engineer in operational techniques." It should be stressed that

civil engineer in Belgium is a quite general term meaning simply that the engineer is not military (this was the original meaning of the term civil engineer in our country); what we refer to as civil engineer is called in Belgium civil construction engineer. "Operational techniques" simply means OR.

The head of this department, Marc Roubens, took a doctorate in mathematics at the Free University in Brussels, working on time series, and some of his doctoral students are still working on this type of subject. Guyton Liebert had just completed a dissertation on Box-Jenkins techniques for economic time series and was to defend the thesis the day after I met him in Mons. Roubens now works on the analysis of preference, and on graph theory—graph theory because each preference relation becomes an arc on a graph. The basic problem is again one of multicriterion decision theory. Roubens calls his method ORESTE because it is a modification of a method developed by the French OR expert B. Roi which Roi called ELECTRE (in the Greek fable, Orestes was the brother of Electra, so this is a sophisticated bit of whimsy). In this problem there are again a number of possible actions or strategies and a number of criteria. One is given rankings of all actions in accordance with each criterion. Some rankings may have cardinality (that is action A is preferred to action B by 3 units) while others may be strictly ordinal (action C is preferred to action D) and the latter may have various kinds of orderings, for example, some may be nonstrict (action E is no worse than action F). One wishes to find a global ranking. Roi's method assigns a weight to each criterion. Roubens' method has no weights but only an ordering of criteria; the orderings of criteria and of actions can lead to a global ordering. Roubens has actually been working with a consumer organization and putting these techniques into practice.

Roubens also works in fuzzy clustering, that is the partitioning of a set of entities into several fuzzy subsets (*ESN* 35-3:124 [1981]) whereby for each entity and each subset there is a membership function between 0 and 1 which describes the degree to which that entity is a member of that subset. If all of these membership functions are either 0 or 1, then we have the classical partition or clustering. Roubens has also introduced a measure of how fuzzy a partition is; this measure is 0 if all entities belong equally to every subset and unity if every entity has membership function 1 in one subset and 0 in all others. This leads to a method of choosing among partitions by minimizing the above measure, thus increasing the number of well determined entities, that is those whose membership functions are nearly unity for some subset.

At the University of Mons the chief OR person is Prof. Jacqueline Loris, who happens to be Roubens' sister-in-law. She works on exceedingly recondite mathematical methods for the analysis of queues, modifying some methods of Marcel Neuts in the US. There is also some work on systems dynamics at the university, and a major international conference on this subject was held there in 1979. I was fascinated to note that the speakers at that conference did not include any of the well known names of the Americans active in this field and did show representation from many countries of Europe.

As one drives from Brussels through Flanders towards Mons, there are no signs for Mons; there are signs for Bergen. After a while there are no signs for Bergen, but there are signs for Mons. Mons, of course, is the French word for mountain, and Bergen is the Flemish (and German) word for mountain. This is Belgium!

This article will conclude next month with descriptions of CORE in Louvain-la-Neuve and of The European Institute for Advanced Studies in Management in Brussels. (Robert E. Machol)

PHYSICS

ANNUAL UK SOLID STATE PHYSICS CONFERENCE

On 5-7 January, 1981, the 18th annual UK Solid State Physics Conference was held in York. Sponsored by the Institute of Physics, the conference included 13 invited papers (of which 11 were plenary) and 89 contributed papers. In size and ambience this meeting was similar to the now discontinued American Physical Society winter meeting in the west. The format of the conference was arranged so that each morning and each afternoon there were two plenary sessions followed by a short break and then by four simultaneous sessions of contributed papers. The conference secretary was Dr. J.A.D. Matthew of the University of York. Topics covered were the usual solid state ones: Magnetism, Semiconductors, Metals and Alloys, Surfaces, Insulators and Theory. Some observers thought that this meeting had less theory than usual.

In addition to a Solid State Physics Conference, two symposia were presented:

Inorganic Compounds with Unusual Physical Properties, arranged by Dr. P. Day (Univ. of Oxford); and Diffusion and Migration In Semiconducting Materials, arranged by Dr. B. Tuck (Univ. of Nottingham). Most of the invited papers were part of these symposia.

The University of York is relatively new, with most of the buildings dating from the early 1960's when English universities enjoyed a building boom. Until the day before the meeting when a cold spell arrived, the weather in England had been generally mild. This change in weather coupled with the fact that the university had been shut down for the Christmas holidays made for a cold reception in the lecture halls. Even with the heat turned high on Monday the long-time constant of the halls made it cold enough so that many people attended the sessions wearing overcoats.

In one of the sessions devoted to unusual physical properties, Dr. A.T. Howe (Univ. of Leeds) reported on proton conduction in $HUO_2PO_4 \cdot 4H_2O$ (HUP), β-KOH and other materials. Howe noted that HUP in particular may be important in future technology. It is a solid electrolyte which may possibly be used in fuel cells to conduct charge between an O supply and an H supply. It has a high energy density compared to lead acid storage batteries and it has other desirable attributes: it is stable to 40° C in air, insoluble in water, and has a relatively high conductivity ($\sim 10^{-2} \Omega^{-1} cm^{-1}$ at room temperature). In this material the U atoms are octahedrally situated in an H bonded water network which forms layers perpendicular to the c axis. Within the layers, domains form probably as a result of the orientation of the H bonds.

A phase transition occurs at about room temperature (280 K); the higher temperature phase being conducting. Conduction in HUP is anisotropic with $\sigma_{\parallel} > \sigma_{\perp}$, a fact thought to be explained by a mechanism which is a combination of hopping of the protons and rotation of the water molecules so as to provide a continuous path for the positive charge flow.

Above the transition temperature, the water molecules are thought to rotate and provide the charge flow path; below the transition temperature the water molecules are expected to be locked in place. One would expect to observe a heat capacity anomaly if this were true but Howe said that no such measurements had yet been performed on HUP. Howe also noted that β-KOH may be commercially interesting. It is usable at much higher temperatures than HUP which tends to lose the water of hydration and KOH has a conductivity only about 1 order of magnitude lower than HUP.

In the same session, D.J. Machin (Univ. of Manchester) discussed the work he and B.J. Blundell did on superoxide ions (O_2^-). First observed by them in barium and strontium titanates and zirconates with silver added, the superoxide ions were also observed in the pure materials ($BaZrO_3$, $BaTiO_3$, etc.) The main evidence for presence of the superoxides is an absorption at $g = 2.000 \pm 0.005$ in the room temperature EPR spectra of the compounds. Machin reported that they had detected spontaneous formation of the superoxide ions in ternary and quaternary oxides at temperatures between 1,000 and 1,200°C in air. Under the same conditions the superoxides were not observed in the separate binary reagents before combination. Machin emphasized that the resonance is not found in the pure metals and therefore must be originating from the ^{17}O. The only paramagnetic species of ^{17}O is the superoxide O_2^-.

Machin said that he would like to redo these experiments using ^{17}O as a probe, but that it is difficult to prepare small amounts of these compounds by reacting with a small amount of tagged water (containing the ^{17}O). At present he and Blundell are devising an appropriate approach to this materials preparation problem.

Transparent Cr ferromagnetic compounds were discussed in an invited review paper by Dr. P. Day (Univ. of Oxford). Day pointed out that most of the very few known transparent ferromagnets consist of the alkali or rare earth metals combined with the $CrCl_4$ complex. They are mainly 2D Heisenberg ferromagnets, many with a modified tetragonal K_2Ni_4 structure. In $RbCrCl_4$ which is typical, the structure is nominally tetragonal; however, single-crystal neutron scattering experiments show that there is a tetragonal Jahn-Teller distortion in the base plane perpendicular to the c axis so that the true structure is orthorhombic. The effect is very small, similar to that which must occur in ferromagnetic Fe or Ni as a result of the breaking of the cubic symmetry by the preferred direction of magnetization. Transparent $RbCrCl_4$ has green color as a result of two absorption bands (centered at 16 and $18 \times 10^3 cm^{-1}$) in the visible range. The bands are very sensitive to magnetic ordering. As the temperature is lowered the bands diminish and then essentially disappear so that there is very little absorption anywhere in the visible range and the crystal becomes transparent. The intensity of the transmitted light changes by a factor of over 1,000.

Radiant beam annealing of ion implantation damage in semiconductors was discussed by Dr. C. Hill (Plessey Research

Center, Towcester. See *ESN* 34-5:317 [1980]) who pointed out that short annealing times (t<20 sec) are needed in order to prevent the implanted dopant from diffusing away from the surface.

Hill said that these desired times are difficult to obtain by conventional techniques when annealing 1 μm thick semiconductor films which have been deposited on relatively thick Si substrates. A radiant beam, however, has the possibility of depositing the energy required for annealing at the proper place (in the film). Both electrons, of about 1 Å (150 eV) wavelength, or CO_2 laser light have been used with pulse lengths between 1 ns and 10 sec.

Ideally, Hill pointed out, the absorption length of the radiation should be approximately equal to the film thickness of 1 μm giving an absorption coefficient of about $10^4 cm^{-1}$, and a red or green laser would satisfy this requirement. He further noted that the beam regimes could be classified into three categories: adiabatic ($t \sim 100$ ns), in which all the heat energy is deposited at the front of the slab; isothermal ($t \sim 10$ s), in which the slab is heated uniformly; and thermal flux, which is in between the two extremes. Each of the regimes can occur and can be utilized.

Several papers were devoted to magnetic elastic interactions. Dr. R.J. Potton (Univ. of Salford) discussed symmetry classification of magnetostrictive bending modes in the helical magnet phase of heavy rare earth metals. Potton's object was to show that inconsistencies arise when simple thermodynamics is applied to helical magnets. He noted that for Dy, Claperon's equation fails in that according to his measurement dTc/dp is negative and ΔV is positive. Potton opined that this inconsistency could be the result of a too simple thermodynamic theory which assumes a shape-independent free-energy density.

Also for Dy near the Neél temperature, Potton found differences between his hydrostatic measurement and the ultrasonic measurements of S. Palmer. Potton found that the particular non-cartesian elastic constant S^{12} which he measured and also calculated from Palmer's ultrasonic data had opposite sign, and thought this difference was a result of neglecting body forces which occur as a result of long range spin-spin interactions within the material. Introducing these interactions leads to a third rank magnetostrictive bending tensor for the helical magnets. During the questioning period it was pointed out by G.A. Saunders (Univ. of Bath) and this author that it is important to assess the propagation of error when calculating elastic compliances from elastic constants or vice versa.

Approximately 50 persons attended an open meeting of the Solid State Subcommittee chaired by Prof. A.J. Forty (Univ. of Warwick) on Tuesday evening. Prof. V. Heine (Cavendish Laboratory) said that next year the Institute of Physics will cancel the Annual Solid State Conference and replace it with the meeting of the Condensed Matter Division of the European Physical Society (EPS) which will be held at Manchester March 22-25, 1982. Heine, who is to be the local chairman for this meeting will try to arrange a large number of invited talks combined with multiple parallel sessions of contributed papers. The meeting will be the second one of a series which began in Antwerp (See *ESN* 34:9-449 [1980]) and Heine hopes to carry the momentum of that meeting forward to 1983 when the EPS meeting will be held in Lausanne. If enough interest can be generated the intent is to have an annual meeting of the Condensed Matter Division of the EPS.

Of vital concern to those present was the future of the UK Solid State meeting. Since attendance had dramatically and inexplicably dropped this year (from 250 to 150) various opinions were expressed that contributing factors were expense, location, and timing. It was pointed out in particular that the number of researchers and students attending was very small compared to other years. Suggestions were made to hold the meeting in London at a hotel and to change the time of the meeting to immediately before Christmas or in the springtime (probably March) between terms. Although no decisions were reached in the meeting which was a forum, not a voting body, it was generally agreed that continuation was worthwhile and that many corrective steps could and would be taken before the Annual Solid State Conference was abandoned. (John R. Neighbours)

SOME SOLID STATE PHYSICS AT SUNDERLAND POLYTECHNIC (UK)

Sunderland is an old, medium sized industrial city located 16 miles southeast of Newcastle on Tyne, where the Wear River flows into the North Sea. It is an historic manufacturing city, with shipbuilding dating from the 14th Century and glassmaking from the 8th Century. Sunderland Polytechnic, which I visited, was formed by the merger of two colleges which both date to 1860. It was the first educational institution in England to have work-study courses (called sandwich

courses in the UK) and today has 3,000 students in full-time and sandwich courses and 1,000 students on part-time study. The Polytechnic has Departments of Art, Education, Engineering, Humanities and Science. In the last named, courses are taught leading to degrees in applied biology, applied physics, materials science, and combined studies in science. Each of these degree programs can be followed either as a 3-year, full-time program or as a 4-year program in which one year, usually the third, is devoted to work in either the industrial or public sector.

In 1975, the Permanent Magnet Association's Central Laboratory, located in Sheffield, was closed. Some of the laboratory personnel came to Sunderland where the Permanent Magnet Centre, now directed by A.G. Clegg, was established. The principal work of the Centre is testing magnetic materials in order to determine the technologically important aspects of the magnetization curve: initial permeability and susceptibility, remanence magnetization, saturation magnetization, coercive force, anisotropy, and the energy product BH_m. Measured in J/m^3 this product is the criterion most used for comparing permanent magnetic materials. The higher the value, the less will be the amount of magnetic material needed to produce a given field in an air gap. The measurements are carried out as part of the research program on magnetic materials and also as a service to industrial users. Clegg said that the stability of magnets is important industrially and that his laboratory routinely conducts room-temperature stability tests as well as measurements of magnetization at elevated temperatures to 600°C. All measurements are traceable to national standards, regularly checked by the UK National Physical Laboratory. In addition, standard metallographic apparatus, electron microscopy and X-ray crystallography are used to characterize the magnetic materials.

Magnetic alloys for research are prepared at the Centre. Clegg told me that he has been working on compounds of Misch-Metal (composition roughly 25 La, 50 Ce, 10 Pr, 6 Nd), a refined mix of the natural mixed oxides, and rare earth cobalt alloys. Measurements have been completed on the ferromagnetic compositions of LaCo, LaCeCo and CeCo, and are beginning on NdCo.

In June of 1980, the First UK Conference on Permanent Magnets was held in Sunderland. The conference was heavily biased for industrial applications with emphasis on the manufacture of sintered and bonded magnets, machining of magnetic material, design of permanent magnet systems including workholding and lifting magnets, and the use of permanent magnets in motors and alternators. The proceedings of this conference were edited by Clegg and are obtainable through the Magnet Centre.

Some microwave acoustic work was described to me by Dr. I.N. Court who along with R.N. Clarke (a PhD student) had been making ZnO transducers for use in the 0.1 to 10 Ghz range. This material has very high single-crystal piezoelectric coupling coefficients, but thin films with the same high values are difficult to prepare. The films grown are usually polycrystalline with a preferential direction, the c axis normal to the substrate. Clarke and Court thought that the spatial distribution of the c axes would lead to the observed lower values of the coupling coefficients of the films and sought to establish a correlation between the distribution of orientations of the c axes of the crystallites and the coupling constants. Their results indicate that some other factor apparently predominates. They investigated stoichiometry, orientation inversions, uniformity and stress in the films, but none of these factors seemed to be dominant. Clarke had already left Sunderland for an industrial position at the time of my visit, and Court told me that he, too, would be leaving shortly to take a computing position since he considered the microwave acoustics group in Sunderland too small to be effective.

Dr. D.S. Crozier and Dr. E.J. Fletcher described some interesting applied physics projects to me. Fletcher works 50% of the time on a wear problem in conjunction with the Mechanical Engineering Department. The problem of wear and lubrication of marine diesels arose with the Docksford Engine Company which builds high-speed, three-cylinder, direct-drive ship diesel engines designed to last the lifetime of a ship. These are large engines with a cylinder diameter of about 1 meter. In the first project they mentioned, Crozier and Fletcher are studying lubrication of the piston rings which are seated in a humped groove in the piston so designed as to wear the piston ring into an ideal parabolic shape. They expect to determine the parameters which characterize film breakdown in the engines when using a particular lubricant which is fixed by the operating conditions. The first stage of this study, funded by the SRC, is a two-dimensional model in which the wear of samples of a piston ring against a rotating steel disc is observed as a function of speed and load. Under

construction is a second stage which will be a one-quarter scale plastic model. In the third and final stage of the research, a window will be installed in a full-scale engine mounted in a test bed and the piston ring motion and wear will be observed under actual operating conditions. Crozier and Fletcher work on this problem because of their expertise in instrumentation, principally optics and electronics. They are attempting to measure wear by performing multiple beam interferometry on the piston ring surfaces, and have encountered problems with this technique in that the Cr_2O_3 coating deposited on the window to balance the reflectivity reacts with the gas mixture in the cylinder.

The second project on which they are working is connected with highway lighting. Many of the major highways in urban England are lighted by sodium vapor lamps in which the barium borate glass containing the sodium is encased in a soda lime glass cover to prevent attack by water vapor in the atmosphere. A mixture of Ne and Ar gas has a low arcing voltage and is used as a starter for the lamp. One problem is that Ar is adsorbed onto the borate glass surface and then diffuses into the interior of the glass where it becomes unavailable. This process weakens the Ar content of the starter mixture, thereby raising the starting voltage and reducing the life of the lamp. The lamps are tubes about one foot long and two inches in diameter and their replacement is a significant part of the costs of highway lighting.

Crozier and Fletcher are studying the surface structure of glass and the mechanism of adsorption using Auger spectroscopy of the B atoms. The transition studied would ordinarily be the KLL one but it is modified by the surface. There is a 4-line complex in the 140-180 ev range with the line at 179 ev being the KLL transition in B; the others are the result of surface structure.

Crozier and Fletcher have measured the line shape of this transition. The true line shape is related to the electronic structure of the surface. The two scientists are in the process of obtaining the true line shape by deconvolution of the measurements with the instrumental function.

Sunderland Polytechnic is an institution where "practical" physics is practiced. I was pleased to see bona fide physics research in areas of immediate interest to industry. (John R. Neighbours)

XUV GAIN AT HULL

Attempts to make an X-ray laser have so far been unsuccessful. Many schemes have been proposed, some have been tried, but the short natural lifetime of the upper laser level and the difficulty of obtaining inversion densities sufficient for lasing have frustrated researchers.

These difficulties have led many researchers to abandon the field. Differences of opinions as to the ultimate utility of X-ray lasers and premature claims of discovery, such as the gelatine gibberish of a few years ago, have not reinforced initial motivations. Success will probably depend on painstaking perseverance with both experimental and theoretical details.

This attention to detail was seen on a visit to the Applied Physics Department, University of Hull, Kingston upon Hull (everyone calls it just Hull), UK. There, Prof. S.A. Ramsden and Reader G. J. Pert are the principals in an effort to establish the physical conditions necessary for X-ray lasing. Their extensive experience in laser interactions with plasmas gives credibility to their report of XUV (extreme ultraviolet, that is, soft X-ray) gain in carbon plasmas.

Population inversion had been reported in carbon plasma by Irons and Peacock (*J. Phys. B.*, Vol. 7, No. 9, p. 1109) in 1974 but their method of plasma production precluded sufficient gain for laser action. Ramsden, Pert, and others also reported population inversion in 1976 (*Phys. Rev. Ltrs.*, Vol. 37, No. 19, p. 1265) but of a magnitude lower than their new results.

The idea is to create a plasma of fully stripped carbon atoms and then to cool the plasma very quickly. On cooling, the electrons recombine with the ions preferentially into the upper levels leading to an inversion of population among the levels. The fully stripped carbon atoms are produced in a plasma created by a laser pulse and the cooling is a consequence of a rapid expansion of the plasma.

The choice of levels is important. Ramsden and Pert have lately chosen the $n = 3$ and $n = 2$ in C^{5+}. The radiation between these levels is the Balmer α-line of C VI at 182.2Å. The natural lifetime for $n = 3$ in transitioning radiatively to $n = 2$ is between 10^{-10} and 10^{-10} sec; so the gain per inversion can be very high, but the processes must be fast. Had the ground state been chosen as the terminal laser level, cascading to it

from all other levels would have made population inversion all that much harder to achieve.

The experiment is deceptively simple. A Nd:glass laser is used to produce the carbon plasma. It consists of a mode-locked oscillator which emits a series of pulses each of about 100 ps. duration. One pulse is selected from this train and is passed through a number of amplifiers and a beam conditioner until it reaches a fast lens system consisting of carefully selected cylindrical and aspheric lenses. This laser system, no surprise to laser-gazers, produces a pulse of nominally 5j in 100 ps, on a good day maybe 10j. The pulse is focused to a line with the fast ($f \sim 1$) lens system. The focal line is 2 mm x 40 μm, and the depth of focus is about 50 μm.

There is but one more feature of this laser which is not of great laser interest but crucial to the experiment. About 10% of the pulse energy is allowed through the system first and is followed some 200 ps afterwards by the main pulse. This is done with a beam splitter and an optical delay. (As an aside to those who have followed the silicate/phosphate glass debate, the Hull silicate glass laser will soon have phosphate glass replacements, the phosphate superiority having been accepted.)

The laser beam is focused on a specially prepared carbon fiber. Fibers ranging from 1.5 to 4.5 μm in diameter have been used. The fiber is held in a chuck at one end and the other, the 1.5 to 4.5 μm end, is free. It is very important that during laser irradiation the free end not be cooler than the rest of the fiber. The fiber is positioned so that its end will be well within the laser fine focus line. The fiber is positioned by microscopes inserted into the vacuum chamber enclosing the fiber and the diagnostic equipment.

The diagnostic equipment now in use includes two grazing-incidence spectrographs which have been absolutely calibrated for the 182 Å line. Previous experiments had included ion analyzers to check on ion velocities associated with the plasma expansion, but since there was excellent agreement with measurement and theory, and since the measurements were repeated time after time, the ion analysis is no longer needed. One of the two spectrographs looks along the axis of the carbon fiber, the other looks transverse to the fiber, actually some 60° to its axis.

The experiment then consists of irradiating the carbon fiber with the 10% prepulse, the main pulse, and photographing the axial and transverse radiation at 182 Å.

A word about the use of the fiber and the prepulse. The prepulse breaks the fiber by a laser-driven shock, allows the relatively cool plasma formed to fill more of the focal volume, improves the coupling to the main pulse, and restricts the number of carbon atoms being heated. These features are essential to the success of the experiment.

Ramsden and Pert concluded there was gain in the plasma in two ways: first, comparison of the Balmer α (182 Å) intensities recorded in the spectrographs, and second, the enhancement of line structure and narrowing of the Balmer α along the axis of the fiber.

Someone once said that physics is the establishment of consensus. And the interpretation Ramsden and Pert give to the experimental results requires consensus for acceptance of their models and theory. I understand that other experts who examined the details agree with Ramsden and Pert's interpretation, and based on their previous major research contributions I would believe Ramsden and Pert have got it right.

The radiation transport of the 182 Å line within the plasma was treated à la Holstein (*Phys. Rev.*, Vol. 83, p. 1159, 1951) with modification for motional Doppler and Stark broadening. Based on this theory, a comparison of the intensities observed axially and transversely to the fiber plasma, gives the gain-length product in the plasma. The highest product measured was 4.5 at a laser irradiation of 8j. At 4.9j laser energy the plasma showed absorption. This comparison and interpretation is critically sensitive to the temperature distribution in the plasma; that is why the position of the fiber in the laser line focus is so important.

A gain-length product of 10 would be enough to get laser operation in the traveling-wave mode, but to get a product of 10 requires an irradiating laser much more powerful than Hull has.

Last summer, the Hull people went to the Rutherford Laboratory to try the experiment on Rutherford's laser which is about ten times more powerful than Hull's. It was not possible to take the complete test chamber to Rutherford, nor was it possible to ensure the exact laser beam characteristics essential to the experiment. As a consequence, the results at Rutherford were not so good as those already obtained at Hull, bearing out the comment made above that the experiment is deceptively simple.

The modeling and theory must include the laser plasma initiation and heating, plasma expansion dynamics, ion-electron recombination kinetics, C^{5+} interlevel

dynamics, and radiation transport. And these coupled processes must be treated in a way thought to be applicable and realizable within the experimental conditions. Pert has charted the modeling and theory in publications (*J. Phys. B, Atom. Molec. Phys.*, Vol. 12, No. 12, p. 2067, 1979 and ibid Vol. 9, No. 18, p. 3301, 1976) and has developed scaling rules which could be used as validity checks in future experiments. He has examined the internal consistencies of his models with detailed dynamic computations and has made predictions of the behavior of isoelectronic species.

It is probably the latter course that Hull will now take, that is, experiments with different isoelectronic species. Such experiments would give additional checks on the models but might require new techniques for making the very small fibers and would require recalibration of the spectrographs for the different wavelengths. A factor of 10 increase in laser power probably would produce lasing action in the C VI spectrum.

XUV lasers is but one of a number of laser-related research efforts in the Department of Applied Physics. Coherent lidar, atmospheric monitoring, lead salt injection lasers, pulsed CO_2, waveguide lasers, excimer lasers, laser satellite ranging, and laser matter interactions are topics under active investigation in this well-established and productive department. (W.J. Condell)

NEWS AND NOTES

DRUG'S EFFECT IS TO LOP 6,500 FEET OFF EVEREST

Doctors in Birmingham (UK) Medical School have found a drug that has the effect of lopping 6,500 feet off Mount Everest. The discovery could have considerable importance for high-altitude climbers and skiers, including soldiers whose mission assignments take them to the higher and less hospitable parts of the world.

The drug is acetazolamide, used in the treatment of glaucoma but now shown by a team of 20 from the Birmingham Medical Research Society to be of value in preventing acute mountain sickness. The condition, caused by altitude, produces nausea and headache in its mild form, but can be fatal. In an ascent of 20,500-ft. Mount Chimborazo, Ecuador's highest mountain, 10 members took the drug and 10 others took a placebo. The results showed that by both subjective assessment and clinical tests, those taking acetazolamide performed better in the oxygen-starved air and had fewer symptoms, although one climber on whom the drug appeared to have no effect had to descend.

Although the manufacturers list a number of side effects for acetazolamide, including dizziness and irritability, the doses given in the study caused no difficulties other than a sensation of pins and needles in the extremities, which eventually wore off.

ROYAL NAVY FALCONS: BIRDS OF PREY SAVING LIVES AND MONEY

For a number of years the Royal Navy (RN) has been breeding, training and flying falcons at air stations in the UK to scare away indigenous and migratory birds, thereby reducing bird strikes by RN aircraft. The concept is simple and inexpensive—especially by comparison to the cost of the aircraft themselves—and it seems to work. The idea was first put into practice at the Royal Naval Air Station (RNAS) Lossiemouth, Scotland, but in 1972 the Falconry Unit moved to RNAS Yeovilton, in Somerset, where it remains today. The unit consists of 15 falcons, 1 chief petty officer and 3 junior petty officers. The birds include 9 Nigerian Lanner falcons (one pair used exclusively for breeding), 4 Lugger falcons from Sri Lanka (one pair for breeding), and a pair of very rare Peregrine falcons (breeders only). The Falconry Unit works closely with the British Falconry Club to improve breeding techniques, and 4 of the 7 falcons regularly flown for bird control were bred in captivity.

Although the RN Falconry Unit is licensed by the UK government to kill 50 protected birds per year with falcons, they do not train their falcons to kill. The falcons are simply flown amongst roosting or migrating birds to encourage them to relocate or alter course.

It is regrettable that more careful records have not been kept by the RN personnel during the entire period of the falcon operations. Nonetheless, the effectiveness of the falcons seems to shine through, despite statistical shortfalls. In addition to driving migratory bird populations down toward off-migratory-season levels, falconry operations have dramatically reduced the number of aircraft bird strikes. Of the 12 bird strikes recorded at RNAS Culdrose in Cornwall during the period 1975-80, 9 occurred during intervals of noncoverage by the falcons—and 7 of those were during the first 7 months of 1975, before falconry for bird control was initiated. RNAS Culdrose provides an interesting test case for falconry because more conventional bird-scaring techniques are not employed there. On the other hand, at RNAS Yeovilton, both falconry and conventional techniques are employed year round. Yeovilton averaged some 3,425 aircraft movements per month (below 1,000 ft) in 1979, and 3,825 per month for the first 11 months of 1980. Five bird strikes were recorded at the airfield during that same time period: 1 bird strike per 16,630 low-altitude, aircraft movements.

It is difficult to state conclusively that falconry at RNAS Yeovilton and RNAS Culdrose accounts for the small number of strikes by the RN aircraft operating there. It is safe to say, however, that, provided the falcons can be economically acquired, falconry for bird control is inexpensive to sustain. It requires a small number of additional personnel over those already engaged in conventional bird-scaring techniques, which must be maintained to offset the inherent limitations of falconry (i.e., night, winds, and bad weather). Viewed as an important element of a comprehensive bird-control program, falconry makes a cost-effective, natural contribution to the solution of an old problem that will persist as long as man endeavors to share the airways with the world's first aviators—the birds. (J.A. Strada)

IDENTITY TEST FOR THE NEUTRON

Physicists at the Institut Laue-Langevin (ILL) in Grenoble, France, are about to start an experiment to investigate the stability of the neutron. They will not be looking at how the neutron breaks up into other types of particle, but at whether it can in effect swap identities with its antiparticle, the antineutron.

The possibility of such neutron-antineutron oscillations has arisen in the wake of the recent surge of interest in the possibility that the proton could decay. The so-called "grand unified theories" that attempt to encompass all the forces of nature, except gravity, in one mathematical framework, allow the proton—once believed to be one of the few stable subatomic particles—to decay. They would break one of the empirical rules of physics, that of baryon conservation.

Experiments at particle accelerators and with cosmic rays have suggested that the total number of baryons—particles, like the proton, believed to be comprised of basic units called quarks—must remain the same. Whenever a baryon is created, an antibaryon with exactly opposite properties must also be created to keep the bookkeeping straight. To keep track of the accounting, physicists have assigned a property called baryon number to particles. This has the value 1 for baryons, -1 for antibaryons, and 0 for nonbaryons. Baryon conservations means that the total number B must remain constant in any interaction.

Grand unified theories allow quarks to change into leptons—particles such as the electron, muon, and neutrino. Several experiments to detect such decays in large numbers of protons are already underway, and physicists have begun to think of other reactions that might be allowed if baryon number is not strictly conserved.

In 1978, the Soviet physicist V.A. Kuzmin suggested that the neutron could change into an antineutron, a change which involves a net change in baryon number of -2. Now a team from CERN, the center for nuclear research in Geneva, the UK Science Research Council's Rutherford Laboratory, and the Universities of Birmingham and Sussex (both UK) and Padua, Italy, is about to investigate this possibility.

The researchers are going to use a beam of "cold" neutrons from the reactor at ILL. Such neutrons have relatively low velocities—around 100 m per second—which means that they will spend a relatively long time traversing the 5-m flight path the team has chosen, and so optimize the chance of a neutron changing into an antineutron before leaving the apparatus. Five m from the reactor, the neutrons will be intercepted by a mass of lithium fluoride. Any antineutrons that have formed in the beam will annihilate with neutrons in the neuclei of the lithium fluoride, releasing energy equivalent to the total mass of the antineutron pair—about 2 GeV, twice the mass of the neutron. A sandwich of plastic scintillator and lead surrounding the lithium fluoride will absorb particles kicked out by the energy released in the annihilation, and thus signal the presence of an antineutron.

One problem the experimenters face is that of stray magnetic fields. Neutrons and antineutrons have magnetic moments of equal size but opposite sign, which means that they have slightly different energies in a magnetic field. The presence of even a small magnetic field would therefore stop any tendency the neutron and antineutron might have to exchange identities. The entire 5-m beam will be shielded from fields as small as 0•0001 gauss—the Earth's field is in the region of 0•5 gauss. Thirty tons of iron will protect the apparatus from cosmic rays.

Although grand unified theories do not predict neutron oscillations, theorists have been able to estimate the average timescale of the phenomenon. R.N. Mohapatra (CUNY) and R.E. Marshak (State Univ., Blacksburg, VA) have estimated an oscillation time of about 10^5 s (*Phys. Rev. Lett.* 44 1316). If this is the case, then the experiment at ILL has a chance of observing antineutrons during its 100 days of collecting neutrons at the rate of 45 x 10^7/sq cm/s. But spokesman G. Fidecaro of CERN points out that the experiment is the first of its kind and is not designed to test a theory so much as to look to see if there is an effect there at all. If the oscillation time is less than about 10^7 s then the experiment at ILL will reveal the phenomenon over the next few months.

INMOS LAUNCHES LATEST MICROCHIP DESIGN

INMOS, the UK microchip company whose majority shareholding is held by Britain's National Enterprise Board, made its international debut last month in New York City.

The British company, which is backed by a government investment of £50m, or $100m (see *ESN* 34-12:555 [1980]), unveiled details of its latest product to several thousand delegates from dozens of countries involved in microelectronics at the International Solid State Conference. The new design is called a 64K dynamic RAM, a chip with over 64,000 memory cells for use in computers. It has the added advantage of having cells which can be made to replace others that become inoperative.

ONR COSPONSORED CONFERENCES

OHOLO Conference on "Biomimetic Chemistry and Transition-State Analogs: Approaches to Understanding Enzyme Catalysis," Zichron Yaacov, Israel, 22-25 March 1981.

8th International Gas Bearing Symposium, Leicester, UK, 8-10 April 1981.

International Seminar on the Role of Finite Element Methods in Radiation Physics, London, UK 23-24 April 1981.

Symposium on "Polymer Liquid Crystals—Science and Technology," Portofino, Italy, 18-22 May 1981.

International Conference on Osteoporosis, Jerusalem, Israel, 31 May-4 June 1981.

International Symposium on Locational Decisions (ISOLDE II), Skodsborg, Denmark, 15-18 June 1981.

Conference on "Modification of the Surface Properties of Metals by Ion Implantation," Manchester, UK, 24-26 June 1981.

VIth International Bioelectrochemical Conference, Kibbutz Kiryat Anavim, Israel, 28 June-3 July 1981.

9th International Conference on Operational Research, Hamburg, Germany, 20-24 July 1981.

International Symposium on Advances in Polymer Characterization, Durham, UK, 13-17 July 1981.

International Symposium on Hydrodynamics in Ocean Engineering, Trondheim, Norway, 24-28 August 1981.

4th International Symposium on the Chemistry of Novel Aromatic Compounds (ISNA 4) Jerusalem, Israel, 30 August-4 September 1981.

NATO Advanced Study Institute on "Static and Dynamic Properties of the Polymeric Solid State," Glasgow, UK, 6-18 September 1981.

EUROPEAN VISITORS TO THE US SUPPORTED BY ONR LONDON

Visitor	Affiliation	Navy Lab./Org. to be Visited
	SPRING 1981	
Prof. Evan-Wyn-Jones	Dept. of Chemistry, Univ. of Salford, UK	NRL, Marine Physical Lab., Scripps
Prof. J.W.R. Griffiths	Loughborough Univ. of Technology, Loughborogh, UK	NOSC, NkL, NUSC (April/ May)
Dr. D.E. Packham	Univ. of Bath, School of Materials Science, Bath, UK	NSWC, White Oak (May)

ONRL REPORTS

C-11-80

Report on International Conference on Radio Spectrum Conservation Techniques, London 7-9 July 1980 by G.M. Sokol

This is a review of the highlights of a conference reviewing the results of recent research in developing improved techniques for reducing the requirements for band width in communications. Bandwidth-efficient interference resistant modulation, frequency re-use, cellular organization of short range transmitters and satellite systems are among the techniques discussed. Areas of interest include mobile radio, broadcasting telephone systems, satellite systems, and spectrum planning, assignment and measurement.

C-13-80

Climate and Offshore Energy Resources by P.F. Twitchell

A conference was held in London from 21-23 October 1980 to discuss the relationship of climate to the world's offshore energy resources. A conference focused upon such areas as the impact of oil resources upon the economies of developed and developing countries, the importance of providing climatic data in sufficient time to meet users' needs, and the hazards and financial burdens associated with the development of offshore oil reserves. One of the important achievements of the conferences was the establishment of better communications between the users of environmental data and those charged with producing predictions.

C-14-80

16th International Symposium on Applied Military Psychology by M.J. Farr

This report summarizes the presentations made at the 16th International Symposium on Applied Military Psychology held in Amsterdam from 19-23 May 1980. Departing from previous conference formats, which had one dominant theme, the 1980 symposium emphasized profound discussions of many specific topics. These included the psychological stress of military life, psychological dysfunctioning, evaluation of officer selection systems, attitudes of male officer cadets towards female officers, and the ingredients of heroism.

R-6-80 Laser Research in Ireland, Germany and Austria
by R.S. Hughes

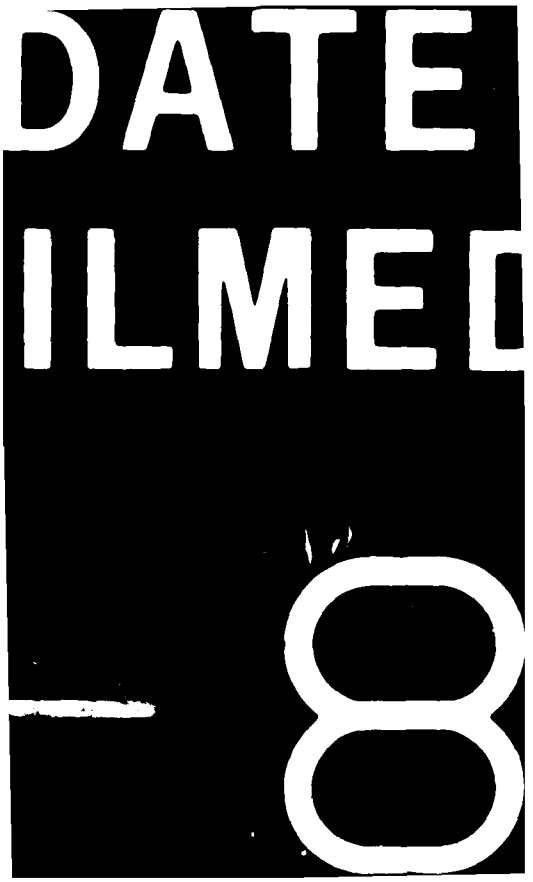
This review contains short summaries of Electro-optics Research and comments on the activities observed. The discussions include the research programs, key personnel, trends, and general observations. The review is essentially complete for Ireland and partially complete for Germany and Austria.

R-9-80 Area Report - Developments in Microwave Antennas and Applications in Sweden, Denmark, and Norway
by T.C. Cheston

This report summarizes research and development work in microwave components, applications, antennas and related devices, found in Sweden, Denmark, and Norway. It describes work at Sweden's Royal Institute of Technology, National Defence Research Institute, Chalmer's University and the L.M. Ericsson Company, Denmark's Technical University, and Norway's Technical University and associate government research organizations.

C-6-80 U.R.S.I. Symposium 1980 on Electromagnetic Waves
by T.C. Cheston and D.K. Cheng

The 1980 International U.R.S.I. (Union Radio Scientific Internationale) Symposium on Electromagnetic Waves was held in Munich. The report reviews the symposium and some of the papers.


DATE
ILMED
8